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Vol. 23 AUGUST, 1931 No. 8

WATER RIGHTS IN CALIFORNIA[1]

By W. G. Irving[2]

"Till taught by pain
Men really know not what good water's worth;
If you had been in Turkey or in Spain,
Or with a famished boat's crew had your berth,
Or in the desert heard the camel's bell,
You'd wish yourself where truth is—in a well."

Thus spoke Lord Bryon in Don Juan.

Such has been the case during the life of man of which we have any record. Water in excess of the amount necessary to satisfy human wants is of little value, but water in sufficient amounts for that purpose is the price of life. It is only when the pains of thirst afflict us that we really know "what good water's worth."

The value of good water is more generally recognized in the arid regions of the earth than elsewhere. In such regions water is usually evident in the form of torrential floods, which rush from the hills to waste themselves upon the plains below, or are lost in the sea. What little water remains is found running in tricklets down comparatively dry washes or in springs or potholes. During the long dry months of the summer, these potholes and springs were in early days the sole source of supply to slake the thirst of human beings, and their wan-

[1] Presented before the California Section meeting, October 30, 1930.

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dering herds. In that time the possessor of a well was a subject of envy to his neighbors. In the Holy Land, Abraham and his sons fought valiantly to obtain possession of the springs that made their abundant flocks and attendant wealth possible. After one of the great famines in the land of Abraham, Isaac in search of water and pasture went to Gerar. There he waxed great and grew fat and the Philistines envied him, "for all the wells which his father's servants had digged in the days of Abraham, his father, the Philistines had stopped them and filled them with earth." Isaac departed therefrom.

"And Isaac digged again the wells of water, which they had digged in the days of Abraham his father; for the Philistines had stopped them after the death of Abraham; and he called their names after the names by which his father had called them.

"And Isaac's servants digged in the valley, and found there a well of springing water,

"And the herdsmen of Gerar did strive with Isaac's herdsmen, saying, The water is our's; and he called the name of the well Esek; because they strove with him.

"And they digged another well, and strove for that also; and he called the name of it Sitnah.

"And he removed from thence, and digged another well; and for that they strove not; and he called the name of it Rehoboth; and he said, For now the Lord hath made room for us, and we shall be fruitful in the land."

This strife for water, which is so well illustrated by the above quotation from Genesis, has been going on from that day to this, in regions where the climatic conditions are similar to those which existed two thousand years ago in the lands occupied by the tribes of Israel. The history of that race is shot through with expressions prophetic and otherwise, which make plain the value attached to water there. Thus, in the prophesies of Isaiah, in which is pictured a land of beauty and happiness, it is said:

"Then shall the lame man leap as an hart and the tongue of the dumb sing; for in the wilderness shall waters break out, and streams in the desert."

The water troubles of the Jewish race in their home land have been transplanted to a land similar in climate and topography. Southern California is in large part like the lands of Judea. Here water is the measure of development and of prosperity. Today the local supply is deficient in quantity. There is not enough to irrigate all the lands which would become fruitful and productive if water

were applied to them, nor is there sufficient to meet the constantly growing demands of the rapidly increasing populations of our cities and towns. The efforts to obtain water for these purposes has lead to continual strife—strife not usually with arms in hands, but strife the arena of which has been in the courts of justice—and it is this strife that has made necessary the large body of law in this State which deals exclusively with water rights.

It is my purpose, in the time at my disposal, to attempt to give you a rough picture of water rights in this State as they now are defined.

During the years that water rights have been the subject of litigation in the courts of this State they have classified themselves into three divisions: First are the rights of riparian owners; second, the rights of appropriators; and third, the rights of the owners of land overlying subterranean sources of supply. There is, as a matter of fact, a fourth class, which is known as "Pueblo rights." These Pueblo rights were granted by Spain at the time California was a dominion of that kingdom, or by its successor, the Republic of Mexico. So far as I am aware, there are only three or four of these rights extant, namely: the rights of the City of Los Angeles in the Los Angeles River; the rights of the City of San Diego in the San Diego River; and possibly one or two others. Such rights are interesting, but as they apply to such a limited portion of the State, it is not necessary to dwell upon them here.

While riparian rights have been, in point of time, recognized by the courts at an earlier period than those of an appropriator or overlying land owner, yet, as a matter of fact, appropriative rights first came to attention in California in the reported decisions of its Supreme Court.

Upon the discovery of gold in this State, which at that time was under the rule of Mexico, there was an immediate American invasion. In the year 1849 one hundred thousand Americans arrived in California, all seeking to extract gold from the valuable ore therein found. The only known method of obtaining the same from the ore at that time, was by the use of water; and the only available water was the water flowing in the streams in the vicinity of the mines. The first miner to locate a claim would naturally divert, from the stream in his neighborhood, sufficient water for his purposes. The second comer would follow the same procedure, and if there was enough water in the stream to supply both, nothing was said. As prospectors in-

creased in number, there came a time when the waters of any particular stream were insufficient to supply all those claiming the same, and the result was that some rule had to be devised by which the rights of the first users could be protected. By reason of this conflict of interest, the miners developed for themselves a rule which is still found in the jurisprudence of this State. The rule is that the first appropriator from the stream has the prior right to the amount of water necessary for his purposes, and others shall only take the surplus. This, in short, was the initiation of the law of appropriation of water as we know it in California. This matter we will refer to hereafter. It may be said here, however, that the law of appropriation in California really preceded, in time and in recognition, the law of riparian rights.

I take it, however, that you are not so much interested in the history of the development of the law defining water rights in California, as you are in the present day definition of those rights. With that in mind, they will be considered in the order above named.

RIPARIAN RIGHTS

California derived its riparian doctrine from the common law of England. It is doubtful if it was the intention of the legislature of this State to recognize riparian rights, or make the laws pertaining thereto part of its jurisprudence. In any event, the first legislature, after the enactment of such laws as were thought necessary to meet the peculiar needs of the State, and being desirous of providing rules which would control in controversies of a nature not specifically mentioned in the laws adopted by it, enacted a statute, in 1850, as follows:

> "The common law of England, so far as it is not repugnant to, or inconsistent with, the Constitution of the United States, or the Constitution or laws of this State, is the rule of decision in all of the courts of this State."

It was by reason of this statute that the courts of this State, when controversies were presented to them involving conflicting claims to the use of waters of running streams, felt constrained to rule that the common law doctrine of riparian rights furnished the rule of decision, and the same became part of California jurisprudence. It has therefore long been settled that the common law of riparian rights is in force in California.

This riparian right is the right of a riparian owner to have the

stream flow past his land undiminished in quantity and unpolluted in quality, except insofar as it may be interfered with by the lawful acts of other riparian owners. It may be that the riparian owner makes no use of the waters of the stream or needs little of it; nevertheless, the fact that he does not use it does not deprive him of the right. It is a right not gained by use, or lost by disuse. It is part and parcel of his land. Nor is the riparian owner (except as between himself and other riparian owners) limited by any measure of reasonableness. He may take from the stream many times as much water as is necessary to supply his uses and purposes, and so long as other riparian owners are able to do the same, no one may be heard to complain, however great may be the need of water elsewhere. Such, in short, are the rights of an owner of lands riparian to a stream, insofar as they have been defined by the courts here.

There are fortunately however some limitations upon the rights of riparian owners.

In the first place, a riparian owner cannot take the water which he is entitled to use, out of the watershed. Only lands which drain into a stream are riparian, and then only if they border upon or furnish a bank for the stream. The riparian owner cannot sell the amount of water which he is entitled to use upon his riparian lands, for use on non-riparian lands. He may relinquish or abandon his rights, but if he does so, the benefit of such relinquishment or abandonment inures to the remaining riparian owners.

Furthermore, the use of water by the riparian owner is limited to lands that are truly riparian.

Each owner of land in contact with any particular stream has a right to divert therefrom water for the irrigation of his riparian land and for other uses thereon—that is, on the land which borders upon the stream, regardless of how far his holdings may extend therefrom, provided that they have always been held in single ownership since title thereto was acquired from the government. If, however, an owner of land bordering upon a river or stream has acquired the same from diverse sources,—that is to say, if from one man he has acquired the land bordering on the stream, and from another owner he has acquired contiguous property within the watershed, but which at no point touches the stream—then his riparian right is limited to the first parcel. The fact that the area which he acquired from the second owner was in the past severed from that portion bordering upon the stream, deprives him of his riparian right to that property

and to the use of the water of the stream upon the same, unless at the time the original severance was made the riparian rights of the portion not extending to the stream were reserved. If the waters of the stream are insufficient in amount to serve the beneficial uses and purposes of all of the riparian owners, then each of them must abate his use of the water proportionately.

There is a further limitation on the right of the riparian owner. His right to demand that the waters of the stream flow past his land, undiminished in quantity, does not extend to all the waters which may flow therein. What the riparian proprietor is entitled to as against non-riparian takers, is the ordinary, customary and usual flow.

As said in the case of Herminghaus vs. So. Cal. Edison Co. (200 Cal. 81):

"As against an appropriator who seeks to divert water to non-riparian lands, the riparian owner is entitled to restrain any diversion which will deprive him of the customary flow of water, which is or may be beneficial to his land."

The rights of the riparian owner are thus declared to attach only to the "usual and customary flow" of the stream. The phrase "usual and customary flow" sounds simple, but innumerable law suits have been prosecuted and hundreds of thousands of dollars have been expended in an effort to determine just what is meant by that expression, and no definition which will fit every case has been found.

The rule is, however, that the riparian owner has no inherent right to use water which does not constitute a part of the usual and customary flow.

In the case of Lux v. Haggin (69 Cal. 255), which is one of the leading cases on water rights in this State, it was said by the court, that it was not prepared to say but that even where the common law prevails, provision may be made for the storing and distribution of waters the result of extraordinary floods caused by the melting of the snows or long continued and heavy rains in the mountains or near the source of a river, since such an extraordinary freshet would not be the ordinary flow of the stream. There is, therefore, an increment in the waters of any stream in which the riparian owners have no right or interest, except insofar as they may be beneficial to them. These are the waters that occur during times of heavy rain storms and which rush down their course, sometimes overflowing their

banks, submerging agricultural lands and invading towns, and which eventually are wasted into the sea. These waters are storm, flood and freshet waters, to which the riparian owner has no title. These waters are the waters that should be impounded in the mountains before they reach the plain. The difficulty, as said above, is to define the line between the ordinary and customary flow of the stream and the storm and freshet waters to which the riparian owners have no title. This, of course, is a matter of judicial decision. It is impossible in advance of a consideration of the facts in each case, to draw the line between flood and storm waters and the ordinary and customary flow.

As I have intimated above, the strict construction and enforcement of the riparian right may, and frequently does, result in the loss of valuable waters. The people of the State have recognized that fact. In 1926 the Constitution of this State was amended, in an effort to prevent such waste. In that amendment it was declared that the public welfare requires that the water resources of the State be put to beneficial use to the fullest extent and that the waste of the same be prevented. In furtherance of this end, it is provided that the right of a riparian owner in a stream or water course shall attach to, but to no more than, so much of the flow thereof as may be required to supply the beneficial uses and purposes of the owner upon his riparian lands. Whether or not this amendment of the Constitution of California will stand the test of the Federal Constitution, I am not prepared to say. However, we believe it would be a step forward in making possible the development of this State to the utmost. The rights of appropriation which have been heretofore acquired have been in opposition to this riparian right, and when you consider that the area in the State of California which is irrigated by reason of the acquisition of rights of appropriation, is probably one hundred times as great as the irrigated area of riparian lands, it is easy to imagine that this riparian right is of comparatively little consequence. In any event, it is the desire of the people of the State to preserve the rights of riparian owners to the use of so much of the waters of the stream as are reasonably necessary to supply their needs.

APPROPRIATIVE RIGHTS

The next class of water rights is that of the appropriator. An appropriator is a trespasser. During the years of the gold rush in California, little thought was given to the rights of the riparian

owner. As intimated above, the first beneficial use of water in this State was in the mining of gold. The rule as developed by the miners was that the first appropriator had the paramount right to the water of the stream. This rule persisted in the history of jurisprudence in this State long after gold mining became an inconsequential industry. Eventually the rights of appropriators became recognized by the laws of the State, and we have a series of Code sections defining their respective rights. As between appropriators, the first in time is the first in right, so long as the amount diverted from the stream is put to beneficial use and to the extent it is necessary for such use. In early days, when the population of California was scant and agriculture was of little importance, the waters of a stream were more than sufficient to supply the demands made thereon. Therefore, in controversies between neighbors as to water rights, the capacity of the ditch was the measure of the right. Later, as the State developed, the rule was enunciated that an appropriator was entitled only to that much of the waters of the stream as he had actually diverted therefrom. With the passing of time population increases. The available water is not sufficient to meet the demands. A new rule is enunciated. That is: that the amount of water that an appropriator is entitled to divert from a stream is that which is actually necessary to supply his beneficial uses and purposes. As to what that amount may be has been the subject of consideration by our courts in many cases. In the highly developed areas of Southern California we find that orchards thrive and produce abundant crops with two acre feet of water per year on each acre. In parts of the San Joaquin Valley we find the irrigators there following ancient practices and taking any where from four to eight acre feet of water per acre per year.

It is now a fight between ancient practices and modern determinations. Be that as it may however, the law is this in the State of California at this time: that the appropriator is entitled to take so much of the waters of the stream as are actually and reasonably necessary to supply his beneficial uses and purposes.

Water appropriated and diverted from running streams is largely used for irrigation purposes. The appropriator may, if he so desires, change the place of use, provided others are not injured thereby. Or he may dispose of his water rights to others, who may change not only the place, but the form, of use, provided always other rights are not damaged. Thus an appropriator may even take water out of the

watershed of the stream from which it is diverted, but in doing so he must not diminish the flow of the stream below his point of diversion. It is a matter of common knowledge that only a part of the water diverted for irrigation purposes is consumed by evaporation and plant transpiration. A part percolates downward to the water table and eventually joins the stream below the point of diversion. As the right to divert water by a non-riparian owner is almost always initiated by a trespass, and becomes fixed by the lapse of the prescriptive period, his right extends only to the amount that he actually diminishes the flow. Therefore, if 25 percent of the water returns to the stream, riparian owners and appropriators below the point of return will be protected in their rights to use this return water. The appropriator would, however, be permitted to take 75 percent of his diversion out of the watershed for any beneficial use.

Prior to the adoption of the Water Commission Act of 1913, rights of appropriation were initiated by actually taking water from the stream, and if such taking continued for five years under a claim of right, the right became fixed.

Since the adoption of the Water Commission Act, rights of appropriation can only be acquired by applying to the Division of Water Resources, for a permit to divert. The Division will, in response to the application, investigate the existing rights to the use of the water, and if it is of the opinion that a surplus exists, it will usually grant a permit, which, if complied with by the applicant, may ripen into a fixed right. But the Division does not determine rights. It grants permission to divert water, if you can get away with it, as against riparian owners and earlier appropriators.

RIGHTS OF OVERLYING LAND OWNERS

The third class of water rights is that of the overlying land owner—that is, the right of the owner of land which overlies an underground body of percolating water to use and dispose of the same. Prior to the decision in the celebrated case of Katz v. Walkenshaw (141 Cal. 116), it was assumed by the legal fraternity in this State, that the owner of land overlying a body of percolating water had the right to extract the same and dispose of it at his pleasure. The decision in that case, however, revolutionized the conception of the rights to underground water. It was there declared that the right of an owner of land overlying underground waters was limited to the amount of water which was reasonably necessary to serve his beneficial pur-

poses upon his land, and that he had no right to use the same elsewhere, unless there was sufficient remaining in the common source to supply the needs of his neighbors who owned land similarly situated. If there is more water in the subterranean source than is necessary to supply all of the lands overlying the same, then the surplus may be exported for use upon lands not so favorably situated, provided that the exportation of the same shall not unduly increase the cost of obtaining water by other owners. What the limit of this cost may be is changing from day to day. In years gone by, it was uneconomical to raise water for the irrigation of lands to an elevation of 50 feet. Today, by reason of the advance in the art of pumping, water may be raised to an elevation of 200, 300 and 400 feet, and crops produced by reason thereof with a profit to the owner. There is no definite limit as yet determined by the courts as to the increased lift which the owner of overlying lands must submit to in order that a surplus from the underground water body may be exported for use on distant lands.

Rights may be acquired to take water from underground sources for use on non-overlying lands, much in the same manner as rights to divert water from running streams are acquired. Such rights, like those of appropriators, take precedence in chronological order. The first in time is first in right. Unlike the riparian owner, however, the overlying land owner cannot prevent the taking from a surplus by the exporter. He can, however, have a decree entered which will protect him in the full enjoyment of his right to take from the underground water body, should the surplus for any reason disappear.

Such is a rather meager sketch of the law defining water rights. There are many collateral matters which are not touched upon here. Time does not permit. It will, therefore, be obvious that this discussion is not exhaustive.

It will readily be evident to you that the inventive genius of your profession has had a large part in furnishing the courts with opportunities to define and refine the law of water rights.

In the middle of the last century, dirt ditches lost 75 percent or more of the waters diverted therethrough. The use of cement lining has caused a reduction of this loss to a minimum. The result is that the efforts of that branch of the legal fraternity which is seeking to conserve water, have been devoted to inducing the court to have such a matter in mind in determining what is a reasonable amount of water to be lost in transmission.

In a case involving underground water, decided in 1906, it was held that an increased lift of 10 feet was not such a hardship as would justify the issuance of an injunction upon the petition of an overlying land owner against an exporter. As you devise more efficient means of lifting water, the courts will doubtlessly increase the margin of lift. You have built aqueducts which have caused certain provisions of the Constitution relating to taxation to be amended.

You contemplate building in the near future a dam of incredible height, and transporting water therefrom hundreds of miles, with a lift of 1500 feet, and interstate litigation follows. There appears to be no limit to the wonders that you can accomplish.

Still with it all, your works do not equal those of one of the earliest water works men.

"And Moses stretched out his hand over the sea; and the Lord caused the sea to go back by a strong east wind all that night, and made the sea dry land, and the waters were divided,"

and the children of Israel passed over, to the discomforture of Pharaoh.

Again, as the exodus of the Israelites from Egypt continued, they came to Rephidim, and there was no water to drink, and they murmured. And the Lord ordered Moses to go on before the people and take with him his rod, and said:

"Behold I will stand before thee there upon the rock of Herob; and thou shalt smite the rock, and there shall come water out of it that the people may drink. And Moses did so in the sight of the elders of Israel."

Such works have not been equalled. I have faith, however, that you in the near future will approach them.

DISTRIBUTION RESERVOIR DESIGN[1]

By Chester A. Smith[2]

In an editorial published in *Engineering News-Record*, this statement was made: "Failure of a reservoir to hold water is a major disease and one which it is the engineers primary duty to forestall." The writer having been called in to hold post mortems on several reservoirs that have completely succumbed to the disease and having seen several exposures or attacks of the disease on others, this paper shall try to prescribe some antidotes or preventatives that such experiences have taught to avert the disease.

CLASSES AND TYPES OF DISTRIBUTION RESERVOIRS

A distribution reservoir may be defined as a tank or basin which is directly connected to, or "floated" on the normal pressure of a waterworks distribution system as a distinctive class or type from impounding reservoirs, settling basins, receiving and clear water reservoirs.

Distribution reservoirs may be divided into two classes: elevated reservoirs constructed entirely above the ground, as steel, concrete or wooden tanks on steel, concrete or wooden towers, and steel, concrete or wood standpipes; and surface reservoirs constructed on elevated ground areas, having relatively little or no elevation above the ground surface.

There are so many types of reservoirs of several kinds of materials, that in a brief paper on reservoir design, details of construction of all types and materials cannot be thoroughly described. To simplify the subject, the design of the so-called earthen embankment, masonry lined reservoir, has been selected for the more detailed analysis. Many of the principles of this type are applicable to, or should be carefully considered in, the design of other types of reservoirs.

[1] Presented before the California Section meeting, October 30, 1930.

[2] Consulting Engineer, Burns-McDonnell-Smith Engineering Company, Los Angeles, Calif.

PRELIMINARY SURVEYS AND INVESTIGATIONS

Accurate contour maps should be made of each possible available site or of the site selected, and after perhaps several trial layouts of the reservoir as to capacity desired or available, the shape and the approximate depths of excavation determined, test pits or borings should be made to determine the character of material encountered in the excavation as well as the character of soil beneath the bottom of the reservoir, or under the embankment.

An economical design is generally one where the amount of excavation, minus the waste of the top soil stripping, will balance the amount of material necessary to form the embankment. However, the borings may show soil conditions that will require considerable wastage in excavation in order to secure good foundation conditions or to secure proper materials for forming the embankment. The test pits or borings may show wide variations in the kinds of material in the strata or in various portions of the reservoir, and it may be necessary to temper or to mix the varying materials as they are placed in the embankment. Thorough knowledge of existing soil conditions and provisions made in the specifications for mixing classes of excavation sometimes saves a great deal of argument between the engineer and contractor.

EXCAVATION AND EMBANKMENT SLOPES

The character of the material to be excavated will govern to a certain degree the slope of the excavation and enbankment. The slopes should not be greater than the angle of repose of the material when saturated. Excavation slopes for interior embankments are generally not less than $1\frac{1}{2}$ to 1. This slope is about as steep as a concrete lining slab can be safely and properly placed upon without the use of forms, and, is approximately the limit of the angle of repose for a stiff workable concrete, without causing slump cracks. Steeper slopes in shale excavation, or other hard materials have been used with a gunite lining. Inside earthen embankments should never be less than $1\frac{1}{2}$ to 1 and for high embankments, and particularly with certain soils, a 2 to 1 slope is preferable.

The outside slope of an embankment should be at least $1\frac{1}{2}$ to 1, and 2 to 1, or $2\frac{1}{2}$ to 1, is preferable for high embankments.

SELECTION OF EMBANKMENT MATERIALS

The ideal material for embankment construction is a mixture of clay and sand, fine gravel or decomposed granite, well pulverized, that will bind together when moistened and rolled. Clays, adobes and certain kinds of soft shales, will swell when moistened or wet, and shrink and contract when dry. Certain types of finely divided silt deposits, or, in some sections of the country, soils termed, "volcanic ash," are very treacherous for use in reservoir construction. The material seems to shrink or dissolve when moistened and flows readily at a very low angle of repose. Where this material is available only for embankment, extreme precautions must be taken to avoid leakage by watertight construction in the lining. The more or less sudden changes in soil characteristics in excavation, either in the bottom or side slopes, require careful consideration in design and construction. Where such changes occur, the excavation should be made from 6 inches to 1 foot deeper, and then refilled and compacted with a mixed or homogeneous material.

In the construction of oil reservoirs for the Shell Oil Company, the excavation for the side slopes was made about 6 feet wider than the finish line, and then refilled and compacted with tempered and selected material. The idea or principle followed in this method is that in large reservoirs the soil strata will not be found uniform, hence unequal shrinkage or settlement will occur, which must be avoided if the lining is to remain solid.

All top soil to a depth of at least 6 inches, and in cases greater depths should be stripped from the reservoir site, and not used in any embankment or reservoir construction. If a dry waterway, wash or gully runs through the reservoir, care should be taken that all porous or silt and detrital deposits are removed and the excavation refilled and compacted with selected material. It is usually good practice to have the entire reservoir bottom extend into solid natural soil, but it is not always practically possible, or feasible. Where suitable material is available for mixing, tempering, wetting and compacting, the reservoir may be safely constructed partially upon filled ground. Some engineers claim that a better embankment or foundation can be made by man and machinery than nature has made by her forces.

PROTECTION OF OUTLET PIPES

All pipes entering the reservoir, as the water supply main, drain and clean-out lines and underdrainage system outlets, should be laid in

trenches excavated in the original firm soil when possible, before any embankment is placed. The pipe lines should be designed to support the weight of the backfill and embankment. Pipe lines passing beneath high embankments should be laid in concrete cradles supporting the lower quarter or half of the pipe, as may be necessary. Concrete cut-off walls or collars to prevent seepage along the outside surface of the pipe, should be constructed every 20 to 30 feet apart, at right angles to the pipe line. These walls should extend approximately 1 foot or more below the bottom and into the sides of the trench and also 1 foot above the junction of the natural ground and embankment.

A concrete collar or thickened slab should be provided around the pipe opening into the reservoir lining. In some cases an expansion or movement joint is provided separating the pipe collar and lining slab.

EMBANKMENT CONSTRUCTION

The safety of the reservoir depends largely upon the solidity and strength of the embankments, hence they should be designed and constructed with the same care and same principles as an earth dam.

After all top soil, roots and permeable material has been stripped from the surface upon which the embankment is to be constructed, the original earth should be plowed, and harrowed thoroughly until well pulverized and mixed, then moistened and rolled and compacted.

The excavated material placed in the embankment should be spread uniformly over the required area in horizontal layers not to exceed 6 inches in depth, then moistened, cultivated and harrowed, until thoroughly pulverized and mixed. Care should be taken in wetting not to produce a springy or quaking condition when rolled and compacted. All rocks or boulders larger than 4 inches in diameter, tree roots, wood or other larger particles of organic matter, should be removed before rolling.

The most satisfactory method of rolling and compacting is by the use of a heavy roller having a number of projecting lugs about 4 to 6 inches long on the roller wheels, or what is termed a pethrolithic tamper or "sheeps foot" roller.

The inside embankment should be carried approximately 18 inches beyond the finished line for the base of the lining, in order to give working space for the tamper or roller to thoroughly compact the embankment. After completion of the embankment this excess

embankment width should be trimmed off by hand to exact subgrade for the lining.

Density and tenacity of material in the embankment is practically necessary for a safe structure of this type. If the embankment runs to too great a percentage of sand, gravel, loose rock or disintegrated granite, it may be necessary to borrow or haul in clay, loam or other fine binding material to fill the voids in the main excavated material. The grading and percentage of fine and coarse material is similar to the proper portioning of a concrete mixture.

When sufficient clay or material of this nature cannot be economically secured for making a firm and practically impervious embankment, then greater care should be taken to secure a watertight lining.

RESERVOIR LINING

Reservoirs constructed thirty to forty years ago, were generally lined with brick or rubble stone masonry and water tightness was secured by mixing and puddling the soil beneath this lining. Practically all modern construction employs some type of reinforced concrete or gunite for floors and lining.

A dense concrete is desired, and the proportioning of aggregate should be approximately 1 part cement, 2 parts sand and 4 parts rock or coarse aggregates, the relative proportions varying with the local character of the sand and coarse aggregate. For sloping walls, the water content should be kept low as possible to secure a good workable mixture. Some specifications call for a slump test not to exceed 1 inch.

The required thickness of floor slab and the slab for side slopes, depends somewhat upon the character of the soil and embankment. Under the most favorable conditions, the minimum thickness should be at least 4 inches.

Unless exceptional local conditions require heavier construction, a well proportioned and compacted concrete slab thicker than 8 inches is not necessary for water depths up to 40 feet.

A number of reservoirs have been lined with gunite, ranging in thickness from $1\frac{1}{2}$ to 4 inches. A double concrete slab with a fabric waterproof membrane between the slabs or bottom slab of concrete supporting the membrane with the top or cover slab of gunite, has been used in several designs.

Reinforcement

"Chicken" wire fencing, expanded metal, welded wire fabric, and steel bars, have been used for slab reinforcing and in some cases, apparently there has been little thought given to the function of the reinforcing, and its placing and required steel area. The earth foundation or embankment should be designed and constructed to support the water pressures and super-imposed loading, and the slab is not designed to resist bending moments over any particular span between supports. The reinforcement is to care for temperature, curing and drying stresses within the slab. In "Concrete Building Construction," Crane and Nolan, it is stated that concrete expands with moisture during curing, about 0.02 percent, and contracts upon drying out 0.06 percent in length.

The action of contraction and expansion due to temperature changes, is well known. "Contraction is often more serious, although cracks are by no means necessarily dangerous," is quoted in *Concrete, Plain and Reinforced*, by Taylor, Thompson and Smulski.

The percentage of steel area should range from 0.2 to 0.4 percent of the cross sectional area of the concrete slab. The lower value is used in floor and side wall slabs where reservoirs are covered and not subject to great ranges in temperature changes. Some authorities recommend the higher limit for special watertight work.

The steel should be well embedded in the slab and for slabs 4 to 6 inches in thickness, the steel placed in the center, rather than in the lower section to obtain bending strength, will obtain better results for the real purpose of the steel. In many cases where concrete slabs have been removed or examined, the steel has been found exposed on the lower surface of the slab, or so lightly embedded that it practically has no bond with the concrete.

Woven or welded wire fabrics have their advantage in usually higher tensile strength and give a more uniform and closer spacing of the reinforcement. However, their disadvantages are that the material is "springy" and hard to hold in the proper position, during construction. Steel bars of proper size and spacing are more easily placed and held into position, especially with the use of "chairs."

Expansion joints

There is a wide difference in opinion or at least in the general practice in the spacing and use of expansion joints. The object of a joint, as stated by Crane and Nolan, "is to provide a plane of separa-

tion so that free movement of two adjacent parts may take place." Therefore, the term "expansion joint" as commonly used, may be better defined especially in reservoir construction, as a "movement joint," as the movement may be from contraction and expansion, or from an unequal settlement of the supporting earth. It is the writer's opinion that joints should not be spaced over 35 to 40 feet apart for expansion and contraction in well reinforced slabs, and prefers in most cases less distances between joints. Where unequal settlement may occur due to a slab extending over an area made up of excavation and embankment, joints should be provided every 15 to 20 feet.

Inasmuch as the joints were expected to move, the joint should be made of a type that will allow movement and still remain watertight. Two principal types are used, one with a flexible metal stop or tongue with the ends embedded in the adjacent slab, and the second with a plastic or mastic filler that will compress or expand with the movement and keep the joint sealed. Soft copper and lead are the most generally used metal stops, and a compound with a coal tar pitch or asphaltum base, is used for the mastic filler. In addition to the mastic filler, one or more layers of a cloth fabric saturated with asphaltum or pitch, mopped on over the joint with the ends extending from 6 to 12 inches onto the adjacent slabs is used to provide an additional water seal. Some interesting tests with these various types of joints were conducted by P. Diederich, Water Superintendent of Glendale, California. A mastic joint 6 inches deep and approximately $\frac{1}{2}$ to $\frac{3}{4}$ inches wide, showed water percolation through the joint within a few minutes under 10 to 15 feet head of water. The same joint, protected with treated fabric strips showed no percolations for heads up to 150 feet. However, when a small puncture was made in the fabric, percolation appeared within a few minutes. The joints with metal water stops were watertight under 150 feet heads.

The mastic joint is usually cheaper and more easily constructed, and can be used successfully, when properly made, for water heads up to 20 feet where absolute water tightness is not essential, but where water tightness is essential, a metal water stop is recommended.

Water proofing

Various admixtures or integral waterproofing materials in the form of a liquid, paste, or powder; surface penetration or surface coatings of bituminous compounds and the asphaltic or tar pitch impregnated membrane methods have been used in reservoir construction for waterproofing.

A dense mixture of concrete of approximately 1:2:4 proportions developing a strength of 2000 pounds in twenty-eight days, is practically impermeable to moderate heads of water. A 6-inch slab or wall of a well graded aggregate, properly placed, and puddled or compacted, should resist a head of 40 feet, and waterproofing mixtures or coatings are not necessary.

If, however, the damp concrete surfaces are to be exposed to freezing weather, then to prevent the spalling or disintegration of the surface, due to freezing, surface penetration or coatings of bituminous compounds are advisable. This may be termed damp proofing, rather than waterproofing.

UNDERDRAINS

A well designed underdrainage system for an embankment type reservoir, and also for other types, may be a necessity to prevent damage or failure, and, in any case it is a good "telltale" indicator of leaks or a change in the conditions of the reservoir. The underdrains will prevent upward hydrostatic pressure on the floor and embankment slabs, due to unequal water levels in adjacent compartments, or on the underside of the lining slabs due to a high ground water plane when the reservoir is empty.

Any appreciable amount of water appearing in the underdrainage system outlet of a well designed and constructed reservoir calls for an inspection and study of its source and cause. Any appreciable increase in flow over a normal allowable amount at any time, is a warning that something has happened and an inspection and investigation of the cause and its remedy may save damage, if not possible disaster.

The soil conditions of the excavation and embankment, spacing of expansion or movement joints, height of embankment and other local considerations have their influences upon the design and layout of the underdrainage system. In large reservoirs it may be advisable to divide the drainage system into several units with separate outlets in order to more quickly locate the cause of excessive leakage that may appear from one section of the reservoir.

In general, the drain pipes should be located at the toe of slope where the side wall lining joins the floor, and also near and parallel to floor expansion joints, and, one or more lines across the face of high embankments.

The drains should be sewer pipe, or short lengths of cast iron soil pipe, laid with open joints in trenches backfilled with gravel up to the

slab. If the soil is tight, the closer spacing of drains is necessary to allow lateral movement of water to enter the drains and a layer of several inches of gravel should be placed between the soil and lining to allow a porous medium for the water to readily percolate into the drains.

STORM DRAINAGE AND OVERFLOW PROVISIONS

Frequently the reservoir location is in a canyon or ravine, and the reservoir construction may block the natural course of the surface waters arising in the drainage area above the reservoir. Ample provision should be made to prevent surface water from entering the reservoir and to provide waterways or conduits to by-pass the storm water around the reservoir and protect the banks from wash or erosion. The capacity of such drains should be computed and designed for maximum intensity rainfalls on the drainage areas. Consideration should be given to the possibility of brush, stones or débris carried down by an excessive rainfall and blocking the waterway or opening thereto.

In some designs an additional provision is made for the emergency of an extreme cloudburst or the stoppage of the waterway, by providing an auxiliary overflow opening into the reservoir at a higher elevation with a similar outlet overflow opening in the wall connected to the waterway or drain at the down stream side of the reservoir. This lower spillway may be at the elevation of the normal water level when the reservoir is full and also serve as an overflow from the reservoir.

COSTS

Accessability of site, amount and character of excavation and local costs of materials and labor are the main factors influencing the costs of construction. There may be many other factors also, as the necessary appurtenances for diverting storm water, drainage, necessity or advisability for landscaping, beautifying the grounds, fencing, etc., that may add considerably to what may be termed average normal costs.

From statistics on actual construction costs, the costs per million gallons, for embankment concrete lined reservoirs with wooden roofs, range as follows:

capacity, gallons	*cost, dollars per m.g.*
500,000 to 1,000,000	18,000 to 15,000
1,000,000 to 4,000,000	15,000 to 10,000
4,000,000 to 10,000,000	10,000 to 7,500
10,000,000 to 15,000,000	7,500 to 5,500

Roofs of tar paper or patented roofing on wood sheeting with redwood or concrete columns, including column foundations, usually cost from 20 to 25 cents per square foot of roof area.

In some cases for capacities up to 2,000,000 gallons, a riveted plate steel reservoir may be purchased and erected at less cost than an earth embankment concrete lined or ring tension concrete wall reservoir, either with or without roof.

SOME NOTES ON ELECTRICALLY DRIVEN CENTRIFUGAL PUMPS[1]

By Homer E. Beckwith[2]

In the past few years there has been a rapid change from steam to electrically driven centrifugal pumps, especially in the smaller water works plants. The many advantages of electric power are coming to be more and more realized, but unfortunately in many cases a full knowledge of the nature of centrifugal pumps does not seem to have accompanied their adoption. It is economy of the highest order, therefore, to secure the advice of a competent engineer before purchasing any centrifugal pumping equipment.

Centrifugal pumps are designed to operate under fixed conditions, and any appreciable change from design conditions will result in decreased efficiency.

INADEQUATE INSTALLATIONS

One water company purchased its pump from an ice company, because the ice company had no further use for it and was willing to sell it at a bargain price. How much of a "bargain" this purchase proved to be may be realized from the fact that excess power bills caused by inefficient operation under conditions for which the pump was not designed, have amounted to many times the cost of a properly designed unit.

In another city the pumping units were two 2,500,000 gallon pumps operating in parallel to give a combined output of 5,000,000 g.p.d. These pumps were designed to work against a head of 100 pounds. The time came when these pumps would not carry the maximum day load, and the output was increased by putting the discharge of these two pumps through a 5,000,000 gallon pump designed to operate against a head of 50 pounds. This gave an installation designed to pump 5,000,000 gallons per day against a head of 150 pounds, whereas it was working against a head of only 100

[1] Presented before the Florida Section Meeting, April 3, 1931.

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pounds. It is true that this installation gave an increased discharge, but at considerable cost in efficiency.

In another instance, the clear well was of such a small size that it was necessary to coördinate the flow from the filters into the clear well with the pumpage out of it. As the low lift pump from the river to the filters had a higher rate of discharge than the pump from the clear well to the distribution system, this coördination of flow between the two pumps was secured by partially closing a valve on the discharge of the low lift pump. Throttled down in this manner, the pump had an overall efficiency of approximately 30 percent. A new low lift pump designed for a discharge equal to that of the high high lift pump gave, on test, an overall efficiency of approximately 60 percent. The cost of this new pump was saved in a short time through reduced power bills.

Recently, while testing a pump, it was discovered that a valve on the discharge line was partly closed. The reason given for this was that with the valve open the pressure at the pump was not equal to the design head, and that greater efficiency could be expected from the pump if the valve were sufficiently closed so that the pump were working against its design head. This is true as far as it goes. What was overlooked was that a great deal of the energy output of the pump was destroyed by friction in passing through the partially closed valve. Within reasonable limits, a reduction in pumping head below the design head is accompanied by a reduction in efficiency which is less than the proportional reduction in head. Therefore, even though there is a loss of efficiency, there is some increase in the gallons delivered per kilowatt hour.

In another case, someone neglected to take the friction head into account when figuring the head against which the pump had to operate. As in this particular case the friction head amounted to about 15 percent of the total head, a drop occurred both in efficiency and in discharge rate. The pressure head against which a pump operates includes friction loss and provision must be made for this when planning a new installation. It has been often found that much equipment has been made obsolete by modern design. A large pump, due to wear and obsolescense, gave an overall wire to water efficiency of 57 percent. A modern pump, having an overall wire to water efficiency of 72 percent, decreased the monthly power bill an amount equal to 5 percent of the total cost of the new installation. In less than two years this pump had paid for itself through decreased power bills.

A RAPID METHOD OF CHECKING PUMP EFFICIENCY

The foregoing illustrations should be sufficient to emphasize the importance of watching these pumps to see that they are working under proper conditions, and that they are giving the kind of performance they should give. For some time the writer has felt that some simple method should be available to the average water works operator whereby he could check up on his pumps. Table 1 was worked up for personal use, but may prove to be of interest. A slide rule was used in its preparation, but it should be accurate to a fraction of 1 percent. With this table, it is believed that the work of securing overall wire to water efficiencies will be reduced to a minimum. Table 1 shows the number of gallons pumped per kilowatt hour against a given head, assuming the motor and pumps have efficiencies of 100 percent. A rough check can be made by dividing a month's pumpage in gallons by the kilowatt hours consumed. This gives the number of gallons pumped per kilowatt hour. With the pump running, determine the average total head in feet (including suction) against which the pump works. From the table secure the number of gallons which would have been pumped at that head if the installation were 100 percent efficient. Divide the number of gallons actually pumped per kilowatt hour by the theoretical value given in the table. This gives the overall wire to water efficiency of the installation. To illustrate:

Assume a monthly pumpage of 18,620,000 gallons, a total head of 200 feet, and a power consumption of 20,000 kilowatt hours. Dividing 18,620,000 by 20,000 we get 931 gallons per kilowatt hour. For 100 percent efficiency the tables indicate that the discharge would be 1592 gallons against a head of 200 feet. Dividing the actual discharge per kilowatt hour by the theoretical value we have:

$$\frac{931}{1,592} = 58.5 \text{ percent overall efficiency}$$

A more accurate method of making the tests is to measure the power input for an hour, or other convenient period of time. During this period measure the output of the pump with a pitometer, or any other suitable main line meter. Keep a close record also of the discharge pressure and of the suction. The integrations on most electric meters in pumping stations cannot be read closely enough for short tests. However, the power company will furnish the number of watts consumed for each revolution of the disk, and by count-

TABLE 1

Gallons of water delivered per kilowatt hour against various heads on theoretical assumption that pump and motor are 100 per cent efficient

H = head in feet. G = gallons per kilowatt hour

H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G
1	318,200	51	6,240	101	3,151	151	2,108	201	1,583	251	1,268	301	1,058	351	907	401	794	451	706
2	159,100	52	6,120	102	3,120	152	2,094	202	1,575	252	1,263	302	1,054	352	904	402	792	452	704
3	106,100	53	6,005	103	3,090	153	2,080	203	1,567	253	1,258	303	1,051	353	902	403	790	453	703
4	79,560	54	5,894	104	3,060	154	2,067	204	1,560	254	1,253	304	1,047	354	899	404	788	454	701
5	63,650	55	5,786	105	3,031	155	2,053	205	1,552	255	1,248	305	1,044	355	897	405	786	455	700
6	53,040	56	5,683	106	3,002	156	2,040	206	1,545	256	1,243	306	1,040	356	894	406	784	456	698
7	45,460	57	5,583	107	2,974	157	2,027	207	1,537	257	1,239	307	1,037	357	892	407	782	457	697
8	39,780	58	5,487	108	2,947	158	2,014	208	1,530	258	1,234	308	1,033	358	889	408	780	458	695
9	35,360	59	5,394	109	2,920	159	2,002	209	1,523	259	1,229	309	1,030	359	887	409	778	459	694
10	31,830	60	5,304	110	2,893	160	1,989	210	1,516	260	1,224	310	1,027	360	884	410	776	460	692
11	28,930	61	5,217	111	2,867	161	1,977	211	1,508	261	1,220	311	1,024	361	882	411	775	461	691
12	26,520	62	5,133	112	2,842	162	1,965	212	1,501	262	1,215	312	1,020	362	879	412	773	462	689
13	24,480	63	5,051	113	2,816	163	1,952	213	1,494	263	1,211	313	1,017	363	877	413	771	463	687
14	22,730	64	4,972	114	2,794	164	1,940	214	1,487	264	1,206	314	1,014	364	875	414	769	464	686
15	21,220	65	4,896	115	2,766	165	1,929	215	1,480	265	1,202	315	1,011	365	873	415	767	465	685
16	19,890	66	4,822	116	2,744	166	1,917	216	1,474	266	1,197	316	1,007	366	870	416	765	466	683
17	18,720	67	4,750	117	2,720	167	1,906	217	1,467	267	1,193	317	1,004	367	868	417	763	467	682
18	17,680	68	4,680	118	2,697	168	1,894	218	1,460	268	1,188	318	1,001	368	865	418	761	468	680
19	16,750	69	4,611	119	2,674	169	1,883	219	1,453	269	1,184	319	998	369	863	419	760	469	679
20	15,910	70	4,547	120	2,652	170	1,872	220	1,447	270	1,179	320	995	370	860	420	758	470	677
21	15,150	71	4,482	121	2,630	171	1,861	221	1,440	271	1,175	321	992	371	858	421	756	471	676
22	14,470	72	4,420	122	2,609	172	1,851	222	1,434	272	1,170	322	989	372	856	422	754	472	675
23	13,830	73	4,360	123	2,588	173	1,840	223	1,427	273	1,168	323	986	373	854	423	753	473	674
24	13,260	74	4,301	124	2,567	174	1,829	224	1,421	274	1,162	324	982	374	851	424	751	474	672
25	12,730	75	4,243	125	2,546	175	1,819	225	1,414	275	1,158	325	979	375	849	425	749	475	671
26	12,240	76	4,188	126	2,526	176	1,809	226	1,408	276	1,154	326	976	376	847	426	747	476	669
27	11,790	77	4,133	127	2,506	177	1,798	227	1,402	277	1,150	327	973	377	845	427	746	477	668
28	11,370	78	4,080	128	2,486	178	1,788	228	1,396	278	1,146	328	970	378	842	428	744	478	666
29	10,970	79	4,028	129	2,467	179	1,778	229	1,390	279	1,142	329	968	379	840	429	742	479	665
30	10,610	80	3,978	130	2,448	180	1,768	230	1,384	280	1,137	330	965	380	838	430	740	480	663
31	10,270	81	3,929	131	2,429	181	1,758	231	1,378	281	1,133	331	962	381	836	431	739	481	662
32	9,945	82	3,882	132	2,411	182	1,749	232	1,372	282	1,129	332	959	382	833	432	737	482	660
33	9,644	83	3,834	133	2,393	183	1,739	233	1,366	283	1,125	333	956	383	831	433	736	483	659
34	9,360	84	3,789	134	2,375	184	1,729	234	1,360	284	1,121	334	953	384	829	434	734	484	658
35	9,093	85	3,744	135	2,358	185	1,720	235	1,354	285	1,117	335	950	385	827	435	732	485	657
36	8,840	86	3,701	136	2,340	186	1,711	236	1,349	286	1,113	336	947	386	825	436	730	486	655
37	8,601	87	3,658	137	2,323	187	1,702	237	1,343	287	1,109	337	945	387	823	437	729	487	654
38	8,375	88	3,617	138	2,306	188	1,693	238	1,337	288	1,105	338	942	388	820	438	727	488	652
39	8,160	89	3,576	139	2,292	189	1,684	239	1,332	289	1,102	339	939	389	818	439	725	489	651
40	7,956	90	3,536	140	2,274	190	1,675	240	1,326	290	1,098	340	936	390	816	440	723	490	650
41	7,762	91	3,497	141	2,257	191	1,666	241	1,320	291	1,094	341	934	391	814	441	722	491	649
42	7,577	92	3,458	142	2,241	192	1,658	242	1,315	292	1,090	342	931	392	812	442	720	492	647
43	7,401	93	3,422	143	2,225	193	1,649	243	1,310	293	1,087	343	929	393	810	443	719	493	646
44	7,233	94	3,386	144	2,210	194	1,640	244	1,304	294	1,083	344	926	394	807	444	717	494	644
45	7,072	95	3,350	145	2,195	195	1,632	245	1,299	295	1,079	345	923	395	805	445	716	495	643
46	6,916	96	3,315	146	2,180	196	1,624	246	1,294	296	1,075	346	920	396	804	446	714	496	642
47	6,771	97	3,281	147	2,165	197	1,615	247	1,288	297	1,072	347	918	397	802	447	712	497	641
48	6,630	98	3,248	148	2,150	198	1,608	248	1,284	298	1,068	348	915	398	800	448	710	498	639
49	6,495	99	3,215	149	2,136	199	1,600	249	1,278	299	1,065	349	913	399	798	449	709	499	638
50	6,365	100	3,183	150	2,122	200	1,592	250	1,273	300	1,061	350	910	400	796	450	707	500	636

ing its revolutions for ten or twenty minutes the rate of power input can be closely ascertained. Or the power company might measure the power by means of special equipment. Where more than one pump is taking power through the master meter at the same time, this latter method is the only feasible one.

To enter the tables, the total head in feet must be secured. If the pressure gauge reads in pounds, transfer the pressure to feet by multiplying the pounds of pressure by 2.31. The suction will probably be expressed in inches of mercury. Change this to feet of water by multiplying by 1.13. Also measure the vertical distance between the center of the pressure gauge and the point of suction measurement. The total head then becomes:

Discharge pressure, in feet.....
Suction, in feet.....
Vertical distance pressure gauge (Is above point of suction measurement), feet.....

Velocity head has been ignored, as it is a small factor for the relatively high heads which usually exist in water works operation.

If water is delivered to the pump under pressure, then the pump works against a head equal to the difference between the discharge pressure and the inlet pressure.

From the data secured during the test, determine the gallons delivered per kilowatt hour. As before, divide this by the theoretical value secured from the table for the head against which the pump worked. This gives the overall wire to water efficiency of the installation.

As an example, let us assume an installation where we secured the following test data:

K.W. input to motor	90.0	
Rate of discharge	51,480 gallons per hour	
Number of gallons delivered per K.W.H	572	
Pressure	146 pounds	or 337 feet
Suction	15 inches	or 17 feet
Difference in gauge elevation	1 foot	1 foot
Total head		355 feet
Theoretical discharge at 355 ft. head (tables)	897 gallons	
Overall efficiency	$\frac{572}{897}$ = 64 per cent	

Provided a suction gauge is not available, an approximation may be secured by measuring the vertical distance from the level of water in the clear well to the center of the pressure gauge, adding to this measured distance about one foot for loss in bends, etc.

RESULTS OF CHECKING EFFICIENCY

The solution of each instance of inefficient operation is a problem in itself. No hard and fast rules for procedure can be given. In the case cited of obsolete design, the economical procedure was to replace the pump with one of modern design, keeping the old unit as a standby. In other instances, a change in the impeller will often return the pump to high efficiency. In one case, where a multiple stage pump was working against a high head, it was found that its inefficiency was caused by a defective gasket between the upper and lower parts of the pump case. This permitted the water to flow back from the higher to the lower stages, thereby decreasing both the rate of discharge and the efficiency. A new gasket was all that was necessary to solve this difficulty. In another instance, it was found that some of the ports had become plugged with wood, probably when a filter bed had broken three years previously.

About a year ago, an instance was uncovered where an apparent inefficiency was due to the power meter being set high. As soon as the test figures were in, the striking thing was not so much the low efficiency indicated, as the fact that the motor was apparently taking power at a rate which would have caused it to "burn up" from overloading. The rebate from the power company was thankfully received.

This list could be prolonged almost indefinitely, but it is believed that enough illustrations have been given to show the value of continuous checks. Many progressive operators show on their monthly or weekly reports the number of gallons pumped for the period for each kilowatt hour, of power consumed. This is a splendid practice. Whenever our company, in making these tests, has found a low efficiency indicated, our experience has shown that the power companies and the pump manufacturers are most willing to coöperate in restoring the plant to efficient operation.

Assuming that the motor is about 90 percent efficient, the following overall wire to water efficiencies may be expected from centrifugal pumps of good design:

g.p.m.	*percent*
200	49
400	54
600	58
800	60
1000	63
1500	67

More expensive pumps of best design will often show values of 3 or 4 percent higher than the above figures.

MEASURING OUTPUT OF WATER

Table 1 previously given has another use. Many plants, especially smaller ones, have no master meters. With the old displacement type pump it was possible to secure the approximate amount of water pumped by installing a pump stroke counter and multiplying the number of strokes by the discharge in gallons per stroke. If the pump were permitted to get into a state of dis-repair, this measurement was apt to be in error, but if the pump were kept in good condition it was reasonably accurate. The method about to be outlined for obtaining the output of water from electrically operated centrifugal pumps has possibly a degree of accuracy comparable to the pump counter method.

From the efficiency curve furnished with the pump, determine the pump efficiency for the head under which the pump operates. *The curve will show the pump efficiency only.* The combined pump and motor efficiency, the so called wire to water efficiency, will be about 90 percent of the efficiency shown for the pump alone. From table 1 secure the theoretical gallons per kilowatt hour for the head under which the pump is operated. Multiply this by the overall wire to water efficiency just secured. This gives the number of gallons per kilowatt hour the pump should deliver. Multiply this by the total number of kilowatt hours used over any given period of time and the result should be the number of gallons pumped over the same period. If a curve for the pump is not available and if the manufacturer cannot supply one, approximate results can be secured by using the efficiencies previously given in this paper. To illustrate:

Assume a pump with an efficiency of 65 percent operating at a total head of 200 feet. Then 90 percent of 65 would give an overall wire to water efficiency of 58.5 percent. If the installation were 100 percent efficient, table 1 indicates the discharge would be 1592 gallons per kilowatt hour. With an overall efficiency of 58.5 percent

the discharge would be 1592 × 58.5 per cent or 931 gallons. If the power consumption for the month be 20,000 kilowatt hours, then the total pumpage becomes 20,000 × 931 or 18,620,000 gallons for the month.

While this method of computing pumpage will not, as a rule, give results as satisfactory as those secured from a master meter, it does give a close approximation in instances where a master meter is not available. As a matter of fact, in one instance where this method was used to check the master meter, it was found that it would have been impossible for the pump to have delivered the water shown on the master meter, unless the installation had an efficiency of about 125 percent. This, of course, would be impossible. Whenever a pump installation gives an efficiency over 100 percent, the secret of perpetual motion will have been discovered. In the case just cited the master meter was about 100 percent fast.

In outlining the tests in this paper it has not been intended to supplant the more detailed methods used by professional engineers, but to make available to the average water works operator who does not have an engineering education some method of checking which will give results reasonably accurate. Further, it is desired to awaken water works men to the value of these tests, and to the high dividends which such tests often pay. It is further hoped that this paper has contributed to a more general realization that more must be demanded of a centrifugal pump than that it merely pumps water. It should also pump water *efficiently*. And in order that one may assure oneself that the contemplated installation will give maximum pumpage for the power bill, the advice given earlier in this paper is here repeated. Whenever the installation of pumping equipment is considered, the advice of a competent engineer should be secured and the equipment should be bought on the basis of performance and not price. It will pay.

WATER SUPPLY RESERVATIONS FOR AIRPORTS[1]

By A. H. Heermance[2]

A great many cities have found themselves in urgent need of new or increased airport facilities, and have discovered that, although the city might have ample financial resources, there was no legal way in which money set aside for other purposes might be spent for property which was to be used solely for airport purposes.

There are certain cities where the budget provides for the purchase of land for water supply purposes and where this is the case a combination of airport and water supply area can be arranged which is both economical and advantageous to both purposes.

In Miami we have the municipal airport built on property reserved for the city water supply. It happens that with this particular geological formation that we secure city water by digging wells approximately 75 feet deep at intervals of several hundred feet. These wells are supplied with an electric pump and send water to the central plant located between 1 and 2 miles from the wells, the water is here put through a softening process and then pumped into the city mains with additional pumping stations where necessary.

The present water supply is under the Municipal Golf Course at Miami Springs 5 miles from the center of the city. The reserve water supply is the municipal airport located 10 miles from the city. It consists of 320 acres of land similar to the present water areas. Two hundred acres of these are actual flying area. This portion is fenced in with a 6-foot steel fence on the north and west boundaries. The south boundary is a canal and the east boundary a railroad. Eighty-five acres of the property are held as a safety area to prevent dangerous obstacles from being built which might decrease the effective landing area of the airport. Forty acres which lie across the railroad track from the flying field have been set aside for industrial development.

The actual flying area has no construction on it whatever except the runways which consist of canal rock and cover approximately 15 acres

[1] Presented before the Florida Section meeting, April 2, 1931.

[2] Director of Aviation, Miami, Fla.

of the total 200 acres. This area must, of course, be kept free from obstacles, but whenever needed, wells can be sunk at any point and the electric pumps be placed under ground in concrete water proof structures entered by a trap door in the top arranged to stand the pressure of transport planes landing. Any structure which will hold up the average truck would be alright.

The hangar line in this particular instance is along the western boundary of the airport and there is an area 100 feet wide between the hangars and the edge of the field. This will allow the construction of pump houses above the ground at any point.

The parking area or safety zone outside of the field proper can be built upon at any point, providing the structures do not interfere with the safe conduct of flying operations. It is desirable, of course, to have this area as free from buildings as possible in case a pilot should have motor failure just after taking off or should land in this part with a dead motor with which he was unable to reach the field.

The great advantage to the water supply in the use of this property as an airport is that practically 90 percent of the area is, by the nature of its use, kept as clean and free of all buildings as is possible. A high quality of bermuda sod is grown which protects the soil to some extent from evaporation and probably increases water holding properties of this area above any equal area which does not have the same care.

The presence of large water mains on or near an airport present a factor of safety in the case of fire which is lacking at the present time in practically every airport in the country, due to certain limitations in airport construction such as their size. It is rarely possible to build one within reach of the city water mains and the fire risk can be reduced considerably by arranging fire hydrants along the mains of the water supply system in the airport.

Where a water supply of a city comes from one large well, or a lake, it is possible to build the airport around this area. For convenience it may be necessary to have the flying area on only one side of the lake or well, but the land entirely around it can be cleared off for emergency landings or instruction purposes.

THE GUILFORD PUMPING STATION[1]

By Leon Small[2]

The Guilford Pumping Station is one of several that have been planned during the past few years to enlarge the pumping equipment of the Baltimore water supply system on a scale consistent with the improvements that have been made in the impounding, filtration, and distribution facilities of this system. Supplying all that portion of Baltimore which may be described approximately as lying north of North Avenue, and east of the Jones Falls, with an area of about 36 square miles, it is apparent that the Guilford Pumping Station is one of the major plants of the municipal water system.

The station is located adjacent to the Guilford Reservoir, which is the high point of the Eastern Middle zone of distribution, and takes its suction therefrom, with the water at elevation 340.00. The discharge is carried through the Eastern High Service distribution zone which the station serves, to the Towson Reservoir at elevation 516.00, these conditions requiring the station to elevate the water a net lift of 176 feet. The increase in head due to friction losses raises the net operating head on the smaller units in the station to 188 feet, and similarly, the net operating head for the larger units is 195.5 feet.

The equipment consists of four motor driven, single stage centrifugal pump units, two of these being of 11 and two of 15 m.g.d. capacity each. These units are driven by 400 and 600 h.p. synchronous motors respectively, with separate exciters, all these motors running at 1200 r.p.m. and supplied with 3 phase, 60 cycle, 2300 volt current. Power for supplying the station is brought in through two underground cables at 13,000 volts and stepped down in the transformer-room, which is part of the building, to 2300 volts for the main motors, with taps from the 2300 volt buses further reducing the potential through auxiliary transformers to 230 volts for the station auxiliaries and lighting.

Due to the full water level of the adjacent suction reservoir being but a few feet higher than the ground line at the point where the sta-

[1] Presented before the 4-States Section meeting, April 1, 1931.

[2] Mechanical Engineer, Department of Public Works, Baltimore, Md.

tion is located, the pump units are placed in a depressed portion of the building, this construction giving a positive suction head on the pumps at all times, as well as being the means of permitting a station design that will give the noiseless operation feature which will be touched upon later. Duplicate suction connections are led from the control vault of the reservoir around to the station on the north and south sides, each of these lines branching before entering the building and then carried separately to the pump units. The pump discharges are led from the station separately and connected through a system of valves on the exterior in a manner planned for the least possibility of loss of service from the station in the event of a pipe failure. Access to the pump room is gained from the operating floor above by means of stairwells on the north and south sides, and a system of steps and platforms allow any portion of all pump units to be reached readily. Exciter sets and an air compressor are located on an elevated landing along the west wall of the pump room and from this landing doors lead to a locker room on the north side and a boiler room, for heating the building, on the south side. On the same level as the platform supporting the exciter sets, is the room housing the starters for the main motors. A solid wall is interposed between the pump room and starter room, however, to minimize the damage to the equipment that may result from a flood in the pump room, and access to the starter room can be had only from the floor of the transformer room on the upper level. To reduce the damage that would result from a flood in the pump room, the sump is drained by a 20-inch pipe connecting to a sewer, and for the same reason, the exciter sets and air compressor are elevated above the lower floor line.

Above the pump room is the control room area, from which level the pump units are controlled, with indications of all features of operation brought within sight of the operator. The station is designed for full automatic or manual-automatic control. On the main switchboard, which is set back in a bay of the control room, are centered the controls for the full automatic method, which will be the normal mode of operation; individual control tables for each pump unit serve to centralize the controls when the station is under manual-automatic operation and these also contain signalling and indicating devices that show the operating conditions of each pump unit whether the station is operating under the full automatic or the manual-automatic scheme. A 10 ton motor operated crane is provided to handle the equipment, hatchways with removable covers being built over

each pump unit to allow the equipment in the pump room to be reached.

The 13,000 volt underground feeders terminate in potheads below the disconnecting switches, one set of which will be normally open, with its supply cable as a spare. From the disconnecting switches the circuits are carried over to the top of a switch cell structure, thence passing down through metering and tripping transformers to a manually operated high tension oil circuit breaker. After leaving the breaker, the 13,000 volt lines are continued through underfloor conduits to a point on the floor line at the south wall of the transformer room, from which location they are carried up the wall and across a pipe framework support to form the high tension bus for the main power transformers. Leaving the transformers at 2300 volts, the lines connect to a bus structure mounted on the wall and from this secondary bus, the circuit is led through metering and trip transformers to a manually operated oil circuit breaker on the control panel of the main switchboard, thence being carried down through the floor and connected to a bus structure which is secured to the ceiling of the starter room. From the starter room bus individual feeds for each main motor are carried, through disconnecting switches, to the motor starters, and from these through underfloor conduits to the main motors. Before entering the main low tension breaker, leads are taken from the 2300 volt circuits to supply the auxiliary transformers previously mentioned, these lines being led to the high side of the auxiliary transformers through expulsion type fusible cut-outs. From the low side of the auxiliary transformers, feeders are led to the auxiliary panel of the main switchboard, as well as to the station lighting system.

SUPPRESSION OF NOISE

The Guilford Station is located in a restricted residential development, and when it became known that the City was planning to build a pumping station at this location, this was the cause of a great deal of concern among the local improvement associations. They anticipated that a considerable amount of noise and other objectionable features would be an unavoidable accompaniment of pumping station operation. We had the suppression of noises in mind, however, in designing the plant and we aim to accomplish this in the manner indicated below. The control room floor is supported on a concrete beam and slab construction, from the lower side of which is carried a sus-

pended ceiling, consisting of a system of hangers and light beams, with expanded metal wired to the underside. Over the expanded metal two $\frac{3}{4}$-inch layers of acoustical felt, laid loosely in place, have been placed and the underside of the expanded metal has been finished with plaster. The hangers supporting the suspended ceiling construction are fitted with blocks of cork in such a manner that there is no direct metallic connection between the ceiling and the floor slabs above, all of this construction being designed to reduce to a minimum the transmission of sound waves beyond the confines of the pump room. With the same purpose in view, the concrete slabs covering the hatchways giving access to the machinery in the pump room are supported on strips of cork and at the bottom of the hatchway openings on the level of the suspended ceiling, there are placed false covers, likewise supported on cork strips, and made with a granulated cork fill. The only other openings to the pump room are through the two stairwells, and the sides and bottoms of these are sound proofed in a manner similar to the ceiling construction, with special sound proof doors closing the doorways at the bottom. From preliminary tests which have been made on the efficiency of the sound proof construction, we believe that the operation of the pumps will not create a degree of noise sufficiently audible to be annoying at any point removed 150 feet from the exterior of the station, which is the criterion we have set for the acceptability of this construction. In this connection it should be noted that, in addition to the sound proofing precautions that have been taken in the construction of the building, the pump motors themselves are also of a special design which has for its object the reduction of operating noises to the minimum, and the shop test of these motors under full load demonstrated that the end sought in this construction has been gained.

COOLING OF STATION

The means that have been taken to confine the noise of operation of the pump units to the pump room also effectively confines the heat generated by the operation of the motors and to get rid of the excess heat, which may reach a prohibitive figure, particularly in the summer months, an air cooler has been provided. This is of the surface cooling type and consists of a series of tubes through the interior of which water is passed from the discharge connections back into the suction mains; the exteriors of the tubes are wrapped in a spiral manner with copper edgewise strips soldered in place, the arrangement being one

designed to offer a large area for the absorption of the heat in the air passing over the outside of the tubes by the cooling water on the interior. The cooler is fitted with two motor driven fans, each capable of delivering 7500 c.f.m. of air through the cooler and the air is discharged through directional outlets arranged to give a complete distribution of cooling air over all parts of the pump room. The handling of the cooling problem in this manner, rather than bringing in a supply of cooling air from the outside, in addition to freeing us from the necessity of preventing the escape of noise through the cooling ducts to the exterior, also gives an arrangement that is entirely free of a great amount of dust that would be carried into the pump room if exterior cooling air were used. As it is, the air that is circulating in the pump room will be charged with the initial dust of the room only, plus whatever additional dust gets into the room incidental to the use of the doorways. We believe the result of this arrangement will be very clean operating conditions, second only to a motor cooling system where the cooling medium is confined to an air tight shell surrounding the motor.

AUTOMATIC CONTROL

As previously mentioned, the station is designed for a full automatic method of control and the manner in which we have planned to accomplish this entails certain features which, we think, are entirely novel. The allowable fluctuation of water level in the Towson Reservoir is but a small percentage of the total head developed by the pumps, and for this reason, as well as the remoteness of the Towson Reservoir, coupled with the large variations in pressure that result from the discharge main being a part of the distribution system, it is impossible to depend upon the variation in pressure at the station which results from the varying levels of the water in the Towson Reservoir as means of controlling the pump units. For these reasons, we have adopted a means of automatically throttling the discharge line at the reservoir when the full level is reached. In the pump discharge line immediately before it enters the reservoir, there has been placed a hydraulically operated valve, this being controlled by a pilot valve that is part of a mercury balance device. The balance device consists of a counter-balanced beam connected near its fulcrum to a pilot valve and supporting at its outer end a scale pan, from the bottom of which through a flexible connection is led a pipe to the underside of a small mercury reservoir. The device is so arranged that

when the level in the water reservoir reaches a point about 6 inches below the full line, the head of water from the reservoir level down to the line of the mercury in the mercury reservoir just balances a column of mercury that extends above the mercury level to the inlet level of the scale pan. Further increase in reservoir water level causes the mercury to be forced into the scale pan, this resulting in the overbalancing of the counter-weight, thus placing the pilot valve in the opposite position and closing the throttling valve in the pump discharge. The result of this is a sudden and definite increase in the pressure over the entire distribution system which is reflected at the pumping station, where a contact making gauge closes a circuit, initiating the shut-down of the station. After the pumps cease operating, the distribution system is supplied from the reservoir by means of a checked by-pass placed around the throttling valve and when the reservoir level has lowered about 6 inches, the mercury drops from the scale pan, the counter-weight lowers and causes the pilot valve to return to its original position, the throttling valve opens and all elements are re-established for another cycle of operation. The device is very sensitive with a 6 inch variation in water level and is thoroughly dependable, the Water Department having had a similar one in service at the Pikesville Reservoir for the past seven years, with no failures chargeable against the apparatus.

We have described how the station is shut down when the pumping has been continued long enough to fill the reservoir, and we will now explain how the starting is effected automatically. Included in the control equipment of the station are duplicate timing clocks, susceptible of adjustment for intervals of from two to twelve hours, in fifteen minute increments. The timing interval of these clocks is set by the operator to suit the demands on the station and the capacity of the pump unit that is selected for operation. As long as the pumps are running, the time clocks are merely idling, but when the station is shut down by the functioning of the throttling device at the reservoir, coincidentally the clocks are placed in active operation. When they have reached the end of the timing period for which they have been previously set, the clock mechanism snaps over a contact, initiating the starting of the station. Having accomplished this function, the clocks again assume a standby status and as long as the pumps operate, the clocks are idling, ready to go in service when the station again shuts down.

The starting current limitations for the pump motors, as well as

hydraulic considerations, require that the discharge valves be closed until the pump is up to speed and the means by which we plan to accomplish this is as follows. The admission of water to the hydraulic operating cylinder, for the automatic method of control, is governed by a pilot valve, the position of this being determined by a small hydraulic cylinder located immediately above it. A compression spring in the bottom of the small cylinder tends to raise the piston to the up position, this effecting the main valve so that it will shut. A pressure line from the top of the small hydraulic cylinder passes to the right and connects to the pump side of the discharge valve. When the pump is started and the pressure builds up to a point sufficient to overcome the tension of the sping in the small pilot hydraulic cylinder, the pilot piston lowers, changing the position of the pilot valve so that the pump discharge valve slowly opens, pressure for this purpose being taken by the connection into the discharge main placed beyond the discharge valve; the rate of opening of the discharge valve is regulated by needle valves located in the lines to the hydraulic operating cylinder.

As long as the pump continues to run and the pressure is maintained on the pilot cylinder, the discharge valve remains open; when the shut down indication is given on the control panel, this does not cause the motor circuit to trip open directly, as this practice results in unnecessary wear on the switching mechanism, as well as causing water hammers in the distribution system that may be easily avoided. Instead, the circuits established by the shut-down indication causes a solenoid valve to open, this action bleeding the pressure from the line that is holding the pilot cylinder in the open position, with the result that the spring in the pilot cylinder causes the pilot valve to take the opposite position, closing the discharge valve, the speed of closing, as in the case of the speed of opening, being likewise regulated by the needle valves in the connections. The motor continues to run while the valve is shutting down, and this status exists until the valve is almost seated, whereupon a stop carried on an extension bracket of the main valve tail rod operates a limit switch, which trips the running breaker of the motor starter. When this has been accomplished, the solenoid valve closes, the pressure in the line leading to the pump side of the discharge valve drops to a low value, and all elements are ready for a new cycle of operation.

There is placed around the gates of the main valve a 1 inch checked by-pass, the function of which is to pass a small quantity of water and

thus prevent the pump from overheating in the event a unit starts and the main valve fails to open. The device on top of the cylinder is a reducing motion mechanism by means of which the position of the valve is transmitted through a Bowdenoid cable to an indicator on the control table, located on the floor above. The two pipe lines leading upward from the hydraulic cylinder connections also go to the unit control table and they serve to govern the valve manually when the station is under manual-automatic control. Locked valves are provided for use when the station is under manual control, the object of these being to prevent interference with manual operation by the automatic control elements.

In addition to the automatic control features which have been described, there are a number of other features of interest that cannot be covered in a paper of this length. To summarize these, the electrical controls include provisions for caring for all abnormal conditions that are likely to arise, and in the event of a failure of one unit, a system of selective relays will act to lock out the defective unit and start the next unit that is in order for selection, this process continuing until all four of the units have been exhausted. The air cooler fans start and stop with the operation of the pump units, and the admission of water to the air cooler is also governed automatically.

DEEP WELLS IN SOUTHERN CALIFORNIA[1]

By D. A. Lane[2]

The constantly lowering water tables of Southern California during the present drought cycle, have brought new problems to all communities and individuals dependent on groundwater supply. When it is realized that approximately 80 percent of the water supply is from groundwater, the scope of the problem may be better visualized.

To the pump manufacturer it has brought the problem of lifts hitherto undreamed of, but with the attendant reward of a steady market for their wares.

To the farmer and those who are responsible for an adequate domestic supply of our rapidly growing communities, it has brought the problem of not only maintaining the present supply, but keeping pace with the increasing demand. Any area of Southern California which boasts that it is not concerned about groundwater recession, is fooling no one but itself, and will awaken to the seriousness of its condition too late. The inevitable answer, of course, is an outside source of supply, namely the Colorado River. Until the time that water is available, local conservation must be developed to its utmost, principally by rectification of sewage and spreading of stream flows on the debris cones of the upper valleys.

The immediate result of the lowering water table has been the drilling of additional wells over adjacent territory until many organizations are in active competition in water bearing areas.

In the southern part of the city, the Los Angeles Water Bureau has recently put in an auxiliary supply of wells and attempted a novel plan to prevent interference with the present supply.

The old installation consists of four 16-inch wells varying in depth from 300 to 700 feet. The water level in these wells has dropped over 50 feet in the past twenty-five years, 20 feet of which was in the last five years. To increase the supply it was determined to drill two additional wells in the adjacent territory. Both wells are 16-inch

[1] Presented before the California Section meeting, October 30, 1930.

[2] Bureau of Water Supply, Los Angeles, Calif.

diameter, one with a depth of 1,002 feet and the other 1,203 feet. Neither one is perforated above 840 feet. The static level of these deeper waters is approximately 5 feet lower than that of the old wells. No record of the fluctuation of these deep waters is available.

Due to the small number of wells in this area penetrating these deep gravels, this supply should remain constant for many years.

TYPES OF WELLS NOW IN VOGUE

There are three distinct types of well drilling being carried on in Southern California at the present time:

The old time standard well rig with the shoe from $\frac{7}{8}$ to $1\frac{1}{2}$ inches in thickness, and standard stovepipe casing in 3- or 4-foot joints, perforated when the well is landed on bottom.

The next type, called a "gravel envelope" well, using a standard rig and standard stovepipe casing, but with a cast-shoe of sufficient thickness to leave a space of several inches between the casing and the side walls of the hole. This space is kept filled with pea-gravel as the hole is put down, so that when completed the casing is entirely surrounded with a layer of gravel. The casing is then perforated and additional gravel fed in around the casing as the well is developed.

The other type of "gravel envelope" well is drilled with a rotary rig and equipment. Credit for the origin of this method is claimed by several drillers. The open hole is drilled for the entire depth of the well. Perforated casing in sections of a diameter several inches less than that of the hole is then set and gravel fed in between the casing and the hole. The mud is pumped out and a circulation of water gradually clears out the mud remaining in the gravel.

The principal advantage of gravel envelope wells lies in their ability to develop good producing wells in areas where sand or fine materials prohibit standard drilling methods perforating all strata. For this reason the gravel envelope will produce wells in areas heretofore impossible, while in other districts they may get an increased production by reason of their tapping additional stratum.

LOGS OF WELLS

The collection and study of several thousand well logs in the Coastal Plains of Southern California has shown the variation in classification of the same materials by various drillers.

Due to this variation, engineers or superintendents of water companies having wells drilled for them either should be on the job and

personally identify the materials with the log, or leave the matter of perforation to the driller. It has been my observation that the man who has his hand on the cable is better qualified to judge the materials than any one else.

Some engineers feel that they are not properly directing the work unless they issue the perforation instructions. I know of two instances, where the engineer in charge supplied the driller with a chart to perforate his well, without reference to the log of that well. Why

SCREW PUMP DRIVEN BY A 6-CYLINDER, 125 HORSE POWER TRACTION ENGINE

bother with the log of one well when he had logs of half a dozen in the vicinity to use as a guide.

PERFORATION OF WELLS

The proper perforation determines the future production and value of the well more than any other factor. More wells have been lost through careless or improper perforation than any other reason.

There are many types of perforators on the market, but no new or radical developments have been made for many years. There are two general types now in use. The rolling disk type, cutting six rows of holes simultaneously, and the single blade type. The principal objection to the roller type is that it may have a point broken on one or more disks which will not be observed until the perforator is

withdrawn from the hole, consequently the well is underperforated. It is utterly impossible to re-perforate with safety, and it should never be attempted until every other recourse has been taken. In many districts incomplete perforation means no well.

The single blade type, which requires an individual operation for every hole cut, has the advantage of the operator observing, by the feel, whenever a seam in the casing is encountered and the instant the blade is broken. When this occurs the only loss of perforation is the remaining cuts of the round.

The principal chance of trouble with the single blade is by a careless helper making two cuts in the same hole. In coarse material this may not be serious, but in sand and fine gravel it is disastrous. It is usually the result of too much speed on the part of the crew. My instructions to the crews are to "take your time in perforating, if it requires as long as the drilling of the well," for what is the cost of a few days time compared to the loss of a ten or fifteen thousand dollar well.

A chance for additional perforated area, often overlooked by drillers, is that of perforation from three to five feet below a gravel stratum in a sand stratum. This allows the coarser materials to drop down and bridge off the sand, thereby increasing the yielding power of the well by including part of the sand stratum.

METHODS OF DEVELOPMENT

The method of development used with considerable success by the Department of Water and Power, for several years, is a screw pump driven by a six-cylinder, 125 horsepower tractor engine.

The paramount advantage of the gas engine over other usual motive power is its flexibility of speed. This is a particular advantage at the beginning of the development when a minimum speed is desired to prevent the well from "breaking" suction. Each loss of suction means the deposit of sand in the bottom of the casing and the covering up of perforations. Once these perforations are covered they can only be opened up by the drilling scow or an air lift.

The Los Angeles Water Bureau has found that the most economical procedure of development is to keep the drilling rig over the hole until it is ready for the operating division.

The mast, by back-lashing the walking beam, may be used for setting and pulling the pump. Should a part of the lower perforations

be cut off during developing, the pump may be quickly pulled, the hole cleaned, and the pump reset. The hole may also be cleaned after development and left ready for the permanent installation.

At the start of development the pump is started slowly and run at a constant speed until the water clears up. The engine is then speeded up slightly and maintained until the well again clears. This operation is repeated in succession until the maximum speed of the engine is reached.

At this stage surging is commenced. The clutch is released quickly, allowing the entire volume of water in the pump to drop back into the casing. The instant the pump ceases to revolve backwards, the clutch is thrown in and the engine raced at full speed until the water reaches the ground surface. The clutch is again released and the operation repeated. The second or third surge will usually keep the well pumping for some time before clearing up. The value of this surging operation and its effect was demonstrated to us by some twenty-five wells drilled along the Los Angeles River bed and perforated to within 40 feet of the surface. The water level stood at about 20 feet below the ground surface. As the water returned to the well, there was seemingly no disturbance, but on the quick pickup after the surge the gravel for several feet surrounding the well would move in towards the casing.

DEVELOPMENT OF WELLS WITH AIR

In many places, especially along the south coast, where the water bearing gravels carry an excessive amount of sand, it is difficult to clean a well out after perforating. Air causes the least agitation of any method known and is very often used by installing a 6- or 8-inch eduction line down to the sand with a 1- or 1½-inch air line inside. The drilling or developing crew is able to lower this line gradually as the gravel displaces the sand opposite the perforations. To obtain the best results the air line should be submerged at least 75 percent. The eduction line, however, can be lowered to the full depth of the well.

After the free flowing sand has been removed by the air lift, the developing pump may be installed and the well developed to capacity.

The principal disadvantage of air for complete development is the slow pickup and drop for surging.

AMOUNT OF DEVELOPMENT NECESSARY

Every well should be developed to its maximum capacity, regardless of the quantity it is desired to produce as a constant draft. A study of development curves of many wells drilled by the City of Los Angeles in various locations has proven this.

This is particularly true of wells to be operated on systems with small storage capacity or automatic pressure "cut-ins." Where the operating demand is near the maximum capacity of the well, this constant stopping and starting of the pump is usually a source of trouble to the system. The constant agitation of the water keeps a flow of sand into the well, a part of which is pumped into the system, and a part dropping into the bottom of the well. Eventually this means a sand pumping job and possible collapse of the well.

With the well developed to capacity, a production test may then be made. From this test a capacity and drawdown curve may be plotted, and a safe and economical operating schedule obtained.

Due to the meandering streams that laid down our Southern California valley fills, it is obvious that each well is a separate and distinct problem, to be dealt with and studied individually.

It is this factor of uncertainty that makes the drilling game so fascinating and once a man has entered into it he finds it almost impossible to leave, as his interest expands and creates a hunger for greater knowledge.

METERS SUITABLE FOR CUSTOMERS' NEEDS[1]

By F. R. Berry[2]

In general, meters are divided into four classes, namely, displacement, current, compound and fire service. In this paper the fire service meters will not be considered as they are for a particular purpose and there is usually no selection as to type, and the size is regulated by the requirements of the fire insurance underwriters, modified in some cases by the capacity of the main from which water is obtained.

In practically every instance a large proportion of the customers of a water company or department are classified as domestic. In the past the problem of supplying domestic customers has presented little difficulty to the water works manager, a $\frac{5}{8}$-inch displacement meter being almost exclusively the type and size used for domestic consumers where a single family occupies a premises.

The introduction of flushometers has necessitated further consideration, as a $\frac{5}{8}$-inch meter is not of adequate size to supply such fixtures, and, with the building of new homes using this type of fixture, it is necessary to provide larger service lines and larger meters to meet the customers' requirements.

Flushometers for proper operation require a flow of water at the rate of about 30 gallons per minute and there should be a residual pressure of from 5 to 10 pounds. The friction loss through a $\frac{3}{4}$-inch displacement meter when delivering at the rate of 30 gallons per minute is from 10 to 11 pounds. To this loss must be added the friction loss through the service pipe, plumbing fixtures, etc., and unless the initial pressure is rather high, a $\frac{3}{4}$-inch meter will not adequately supply premises where flushometers are used. The friction loss through a 1-inch meter of the displacement type is from 2 to 3 pounds, and if premises on which flushometers are installed are supplied with service lines of adequate size, little, if any, trouble

[1] Presented before the New York Section meeting, October 9, 1930.

[2] Assistant Chief Engineer, Engineering Department, American Water Works and Electric Company, New York, N. Y.

should be experienced in supplying the customers' needs through a 1-inch meter. The water company or department should be compensated for the furnishing of larger size meters and it is desirable that the rates for metered services provide for either a minimum charge or a service charge which should be in proportion to the rated capacity of the meter, which is substantially in proportion to the area of the nominal size.

When a customer's premises is located where the supply is obtained from a 2-inch line, the use of flushometers necessitating the use of larger size meters should be discouraged as the demand is such that it will interfere with the ability of other customers connected to the same line to obtain adequate service. Where the pipe line, however, is 6 inches or larger in diameter, little, if any, interference has been noticed.

In some localities with which the writer is familiar the pressure on account of topographical conditions is such that it has been found desirable to make the minimum size of meters $\frac{3}{4}$- instead of $\frac{5}{8}$-inch. In such low pressure areas it is not fair to increase the minimum or service charge when the service obtained is only practically the same as would be obtained with a smaller size meter at lower elevations.

For apartment houses and large estates having no intermediate storage, the water works manager has a choice of using a larger size displacement meter or a compound meter. The displacement meter has the advantage in the writer's experience of being somewhat more accurate over a long period at the higher rates of flow; however, at the low rates of flow, before the current section of the meter opens, the compound meter is more accurate. The compound meter also has the advantage of lower initial cost and lower maintenance cost. It has the disadvantage of having somewhat higher friction losses, except when the rates approach the maximum recommended in the standard specifications of the American Water Works Association and the New England Water Works Association.

At locations where the flow during a large proportion of the time is supplied through the current section some trouble has been experienced in keeping the displacement section of the meter in good operating condition as it operates so infrequently that it becomes stuck. This condition, however, rarely obtains, except in some industrial or commercial institutions. It is, therefore, the writer's opinion that in practically all cases where no intermediate storage is

provided domestic consumers, including apartment houses, should be supplied through a compound rather than a displacement meter of corresponding size. This conclusion has been reached largely on account of the relatively larger proportion of the water being measured by the compound type.

Where customers' premises are supplied with an intercepting tank or reservoir, which is equipped with float valves, a straight current type meter may be used to advantage. This is a condition, however, that is rather unusual and current type meters should not be used on such customers except after very careful analysis of the conditions.

In selecting the proper type and size of meter for industrial or commercial consumers, it is frequently desirable to make a careful study of the customers' requirements before an intelligent decision can be reached. This, in the case of new consumers where the type of service cannot be determined in advance, may not be practicable. In such cases the water works manager will have to use his best judgment, and after water service has been commenced a study can then be made and the size and type of installation changed if it is found desirable. In making a study of this kind, good use has been made of a recording pitometer to determine the rates of flow during a representative twenty-four-hour period. The various meter companies supply reliable data as to the accuracy of meters at different rates of flow, together with the friction losses at such rates, and after determining the demands during a representative period it is relatively simple to pick out the type and size meter suitable for the conditions, bearing in mind at all times that a meter should be selected which will not only supply the customers' requirements, but which will also register accurately all water used, and also bearing in mind that other things being equal, the meter of lowest initial and maintenance cost should be selected.

The rates of the water companies and departments, in general, have not been arrived at on as scientific a basis as have the rates of electric companies. They do not provide for a sufficient return in case the average consumption is low and the demand high, as the electric companies express it, a low "load factor." In some industrial plants an independent supply is used for all normal conditions, and a connection to the water works distribution system is used as a standby. It is very unfair to expect the water company to supply such standby service without an adequate return on that part of its investment which would be used to supply the maximum demand of such custom-

ers, as in practically all cases the minimum or service charge does not contemplate this type of service. It is, therefore, of the greatest importance that the water company have the sole right to determine the type and size of meter to be set on the supply line to each customer, or that the schedule of rates provide for an adequate charge for meters larger than are necessary to supply the customers' normal demands.

In determining the size and type of meter to be used, a water works manager should familiarize himself with the standard specifications for cold water meters as adopted by the American Water Works Association and the New England Water Works Association. The specifications are complete and comprehensive, and while the meters as furnished by the various meter companies are capable of delivering the maximum quantities as stated in the specifications, it has been found that, except in unusual cases with high pressures, the maximum capacities as stated in the specifications cannot be used on account of the friction losses obtained at such rates. The friction loss for a $\frac{5}{8}$-inch meter of the displacement type, when delivering at the rate of 20 gallons per minute, which is the maximum stated in the specifications above referred to, is slightly over 10 pounds per square inch. This is the loss in the meter only, and with the loss in the service line, meter connections, plumbing fixtures, etc., there are but few water works plants that can take advantage of this maximum rate except where relatively high pressures are maintained.

THE WATER POWER AND CONTROL COMMISSION OF THE STATE OF NEW YORK[1]

By Russell Suter[2]

Just and equitable apportionment of the available water supply resources of the State among the various municipalities and other subdivisions thereof is the primary purpose of the control exercised by the Water Power and Control Commission over water supply matters in this State. Secondarily, the Commission is concerned with questions of damages, health and safety, but its jurisdiction primarily is based on the question of what part of the State should be served by a given source of water supply.

This is two-edged; both the source of supply and the people served must be considered and a change in either or both may require the approval of the Commission before it may be carried out.

Among other things the Commission has jurisdiction over municipalities and water companies proposing to do the following:

Install a new water works system;
Acquire, condemn or use any source of water supply, supply of water, lands or rights, in connection with a new water works system;
Acquire, condemn or use any new and additional source of water supply, supply of water, lands or rights, in connection with an existing water works system;
Purchase or condemn any existing water works system, if a source of supply is included;
Sink additional or deepen existing wells, even though the land is already owned;
Increase the diversion from a source of supply already in use, by the construction of additional reservoirs, conduits, pumps or otherwise;
Exercise a new franchise;
Supply new territory, even though covered by an old, unused franchise;
Invade territory already supplied by another—except that a city or village may supply any part of itself.

The Commission may authorize any of these things to be done, but its approval must be obtained first.

[1] Presented before the New York Section meeting, April 23, 1931.

[2] Executive Engineer, Water Power and Control Commission, Albany, N. Y.

Approval must be asked for by written petition, which must be accompanied by such maps, plans, reports and other data as may be necessary to give a clear idea of what is desired.

A private applicant must also file a bond.

Subsequent procedure is specified by statute and must be followed. In all cases the Commission must hold a public hearing and must give notice of such hearing by publication of a notice. This takes about three weeks. At the hearing, which is conducted somewhat as is the trial of a case in court, the applicant must present testimony in support of its case; it is not relieved of this duty by absence of opposition. Anyone who wishes to oppose the project may offer evidence and be heard at the hearing, provided that written objections have been filed prior thereto.

Some time during the proceedings, usually after the hearing, an engineer representing the Commission inspects the project and reports his findings to the Commission.

Decision in any case can be made only by the Commission and must be in writing.

The Commission may approve an application only if it can find that

The project is necessary;
All structures are properly designed;
The water will be of suitable quality;
The source of supply should be used by the applicant, with due regard to the rights and needs of others;
Due provision has been made for the payment of damages.

If, in any instance, the Commission cannot so find, it has power to make suitable modifications in the project or to impose conditions and restrictions. If it cannot do this, it must reject the application.

The above determinations are self-explanatory except the last.

Generally, determination with regard to damages requires only that reasonably satisfactory financial arrangements for the carrying out of the project have been made. For this reason the Commission will consider only such matters as have been duly authorized and provisions for the necessary funds made.

There are some cases where this determination is of greater importance. When the execution of a project involves the destruction of entire villages and similar acts of devastation, as occurred in the cases of New York, Albany, Rochester and others, it may be just that resulting damages be paid for on a scale more liberal than that usually used. It is the duty of the Commission to determine in what

cases these consequential damages should be paid. It cannot authorize the petitioner to pay or the courts to determine damages on such scale, but it can decline to approve a project unless the applicant has obtained the necessary powers from the Legislature.

It is not the function of the Commission to act as the guardian of the applicant or of the inhabitants of the applicant; rather it is its duty to protect others against the applicant.

The Commission believes that, if compatible with the rights of others and protection to the general public, the project desired by the applicant should be authorized, even though the Commission may not think it the best available or perhaps either extravagant or unwisely economical. In other words, the Commission as far as may be does not meddle with applicant's right to order its own affairs as it wishes.

After a project has been approved, it may be constructed. It may not be operated until, as built, it has been inspected and approved by the Commission. Such approval is given only on request. The object of this is to assure construction in conformity with approved plans.

At this point the jurisdiction of the Commission terminates. It has nothing to do with the ordinary operation of a waterworks plant. State and local health authorities and such regulatory bodies as may be concerned with rates and service take control, but the Commission does not again appear until some change is to be made in source of supply or area served.

All of these matters are more fully set forth in various pamphlets which may be had on application. The quasi-judicial nature of its procedure makes it impossible for the Commission to select a source of supply or to advocate any scheme; it requires it to be guarded in its statements during the pendency of any proceeding, but no prospective applicant need hesitate to apply for advice or explanation. This is particularly true of the engineering features, which usually can be discussed with some freedom and it is thought that such discussions frequently are beneficial.

This work is carried on by the Department of Conservation, it being under the Division of Water Power and Control, of which division the Commission is the head. The present Commission is composed of Henry Morgenthau, Jr., Conservation Commissioner, Chairman, Col. Frederick Stuart Greene, Superintendent of Public Works, and John J. Bennett, Jr., Attorney General.

PROBLEMS IN WATER RATES[1]

By W. A. Kunigk[2]

In considering the question of water rates in this paper, it is not the intention of the writer to discuss water rate structures as such, but to point out that careful planning in water-works development from ten to twenty years in the future is necessary if the community served is to enjoy the benefits of orderly progress in water system plant growth and a stable water rate that will provide sufficient revenues to carry out projected plans.

As a broad policy, water rates should be reasonably stable over a period of years. This factor becomes especially important when your water rates are being considered by representatives of prospective industries that are desirous to sign contracts for ten years or longer in the future. Men financing large industrial plants usually want to be shown that the City will not only be able to maintain the rate schedule quoted, but that there is a possibility of a decrease, rather than of an increase, in sight at some future time.

Necessary expenditures for additional supply planned, as well as for extensions and betterments in the distribution system to take care of such large industries, naturally have a direct bearing on the rate question. Unless a close study is made of the financial ability of the water department to carry out such a plan of expansion on the rate basis contemplated, serious public opposition might develop and loss of confidence in the public officials charged with laying down the policy of such a utility.

In Tacoma the Water Department is operated as a separate branch of the Municipal Utility Department and does not receive aid of any kind from the general fund or other city departments, except for services rendered. In fact, such service as hydrant service, sewer flushing and street sprinkling, is furnished to the city at a charge of $78,000 per annum, while the Department estimates that the actual cost of such service is in the neighborhood of $135,000. The Water Depart-

[1] Presented before the Pacific Northwest Section meeting, May 15, 1931.

[2] Superintendent, Water Division, Department of Public Utilities, Tacoma, Wash.

ment also pays a rental for office space occupied in the City Hall, as well as for the prorated cost of the services of the City Corporation Counsel, City Treasurer, City Controller and City Clerk. Besides these expenditures the Water Department has for many years paid a 5 percent gross revenue tax into the General Fund. In the current year this gross revenue tax will be 7.5 percent or approximately $60,000. After providing for these items of expense it is important that a sufficient balance remains from the gross revenues to cover all other obligations. Aside from the expense items already enumerated, it is the aim of the Tacoma Water Department to have the gross revenue produce a sufficient income to cover operation and maintenance expense, interest and redemption of outstanding bond obligations and depreciation of plant. The only funds available from the Department for plant replacements, betterments and extensions are, therefore, the moneys from the depreciation fund, surplus and moneys from utility bonds authorized by the City Council. In other words, the Water Department must stand on its own bottom.

On account of the industrial growth the City of Tacoma has experienced in the last few years, with the consequent demand for large quantities of additional water, a number of problems have come up for study and consideration in connection with the water rates that no doubt are more or less typical of the problems other Pacific Northwest cities have had to meet. A brief review of some of these problems will provide a better perspective of the Water Department's finances and their relationship in reference to the water rate problem.

TACOMA WATER SUPPLY

The principal source of Tacoma's water supply is derived from the Green River through a single gravity pipe line, 43 miles long with a capacity of 42,000,000 gallons per day when constructed. This line was completed and placed in service during 1913. Forty-one miles of the total length were built of continuous wood stave pipe and in 1924 it became necessary to start the reconstruction of the wooden portion of this pipe line. A program was worked out whereby every year from 1½ to 3 miles of pipe were to be rebuilt according to the requirements of the physical condition of the pipe so that the whole pipe line will have been renewed by 1940. In view of the fact that the rate of depreciation is computed on a plant value of wood pipe on prewar prices, all of the funds derived from the depreciation allowance are used up in gravity pipe line reconstruction, and new capital must be

added to replace with the more expensive steel and concrete now used. A large part of the program for plant extensions and betterments is, therefore, financed by the issuance of utility bonds.

On account of the advent of several large pulp and chemical plants in the City, it also became necessary to start the development of an additional water supply. In bringing these new plants to the City the Water Department had agreed to furnish water to these industries on a basis of 2 cents per 100 cubic feet, or $26.67 per million gallons for consumptions from 1,000,000 to 3,000,000 gallons per day; for all consumptions over 3,000,000 gallons per day water was to be supplied on a basis of 1½ cents per 100 cubic feet, or $20 per million gallons. Upon negotiations with a number of pulp plant engineers, it became evident that after consideration of other local conditions, such a low water rate as quoted, would act as an additional inducement to locate these plants in Tacoma.

Before the question of the development of this industrial water supply came up for a decision, careful estimates were made of all expenditures and possible gross revenues for a period of over twenty years in the future so that an analysis could be made as to the soundness of the financial ability of the Water Department to carry out this program under existing water rates for ordinary domestic and industrial consumers and the special rate under consideration for the new large industries. Several gravity systems were investigated and estimates were prepared, but it became apparent very soon that it would be impossible to carry out the other financial obligations of the Water Department and at the same time embark on the construction of an additional gravity supply system, involving an expenditure of some $2,500,000 or $3,000,000 without a considerable raise in the present water rates. This, of course, was not contemplated.

A study of our water supply records indicated that with the additional load of from 12,000,000 to 13,000,000 gallons daily on account of the new industries, the deficiency in the supply line would, during the summer months of June, July and August, be as much as 15,000,000 or 16,000,000 gallons daily. During the balance of the year there appeared to be ample capacity in the Green River Gravity System to take care of the City's demands for some years to come. From 11,000,000 to 12,000,000 gallons daily of the midsummer deficiency could be made up from an auxiliary well supply system which the Water Department has maintained in the South Tacoma district since 1908. A study of the general favorable geological conditions in

and near South Tacoma for the development of a large water supply from wells at a low plant investment, in conjunction with the low power rate from municipally owned power plants, led to the decision to develop an additional water supply from wells, equal in capacity to that of the gravity supply system. When this plant is completed the City will have ample protection in case of a complete failure of the gravity supply line during any time of the hazardous reconstruction period. A well system supply of 25,000,000 gallons daily capacity has already been developed and the plan now being carried through promises to meet all expectations under the original estimates without upsetting the present rate schedule. The full effect of the benefits of this development on Tacoma's water rate will, of course, be more apparent in the future than at the present time. Some of the major expenditures for plant reconstruction, betterments and extensions that are part of Tacoma's program will here be enumerated to furnish a better perspective and background indicating the necessity for a comprehensive study of plant requirements and finances for at least twenty years in the future:

1. Reconstruction of the Green River Gravity System between the period from 1923 to 1941. Estimated cost, $3,760,000. Capacity of system to be increased from 42,000,000 to 57,000,000 gallons daily.
2. Duplicate gravity pipe line of 12 miles in length to be built between 1936 and 1939 from a point near McMillin Reservoir to Tacoma. Estimated cost, $995,000.
3. The present air-lift well system of 12,000,000 gallons daily capacity to be replaced by a new well development of not less than 40,000,000 to 45,000,000 gallons daily capacity. Work began in 1930 and is to be completed during 1932. Estimated cost of well development and pumping equipment for individual wells, $200,000.
4. Trunk main progress, especially for industrial area, was begun in 1928 and is to be completed during 1932. Estimated cost, $602,000.
5. Booster pumping plant, capacity of from 25,000,000 to 30,000,000 gallons daily with inter-connections between low and high service systems will be completed during 1931 and 1932. Estimated cost, $120,650.
6. Major trunk mains in distribution system to be completed between 1929 and 1933. Estimated cost, $400,000.

A complete picture illustrating the financial survey of this program and other necessary expenditures and plant income is given in figure 1. This diagram shows a clear analysis of all proposed plant expenditures and estimated income during the entire redemption period of all proposed bond issues. Such a study of expenditures and income commends itself, especially in connection with proposed rate studies.

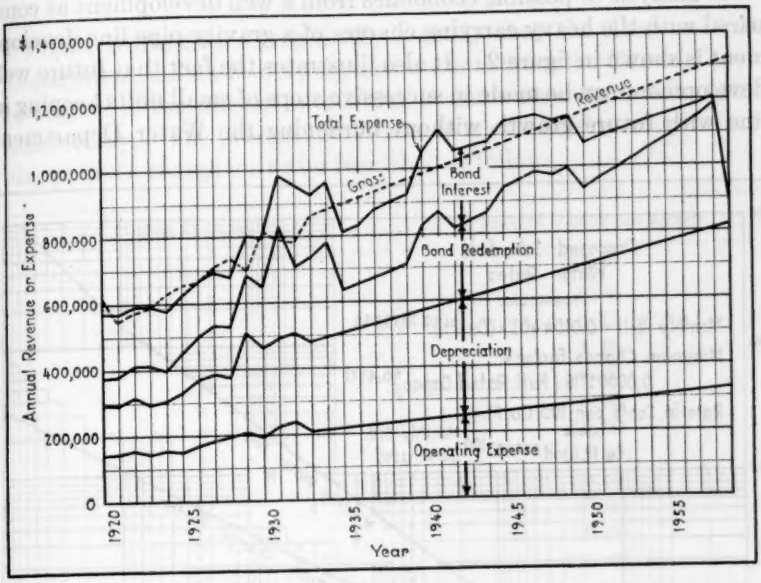
$1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Annual Revenue or Expense
Total Expense
Revenue
Gross
Bond Interest
Bond Redemption
Depreciation
Operating Expense
1920
1925
1930
1935
1940
1945
1950
1955
Year

FIG. 1

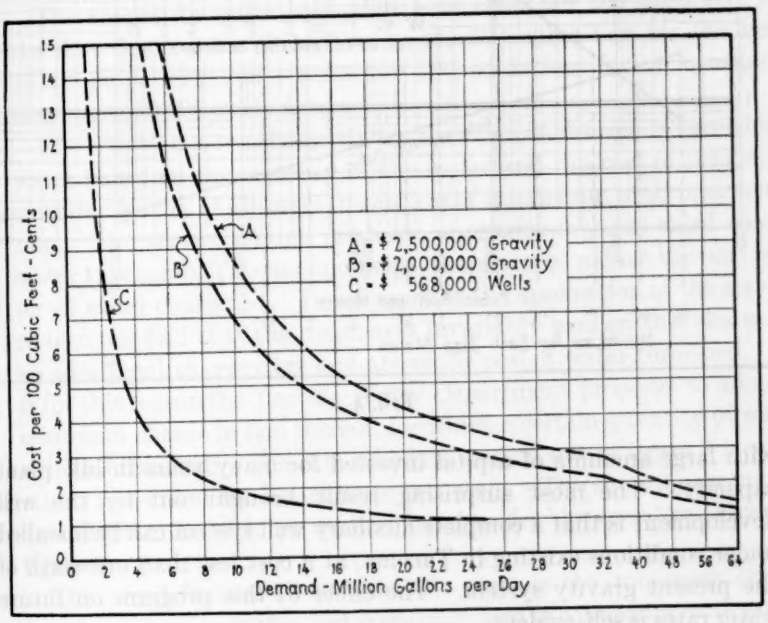
Cost per 100 Cubic Feet - Cents
Demand - Million Gallons per Day
A - $ 2,500,000 Gravity
B - $ 2,000,000 Gravity
C - $ 568,000 Wells
A
B
C

FIG. 2

An analysis of possible economies from a well development as compared with the heavy carrying charges of a gravity pipe line development is shown in figure 2. It also illustrates the fact that future well development can be made in successive steps of small units keeping in line with future growth without burdening the Water Department

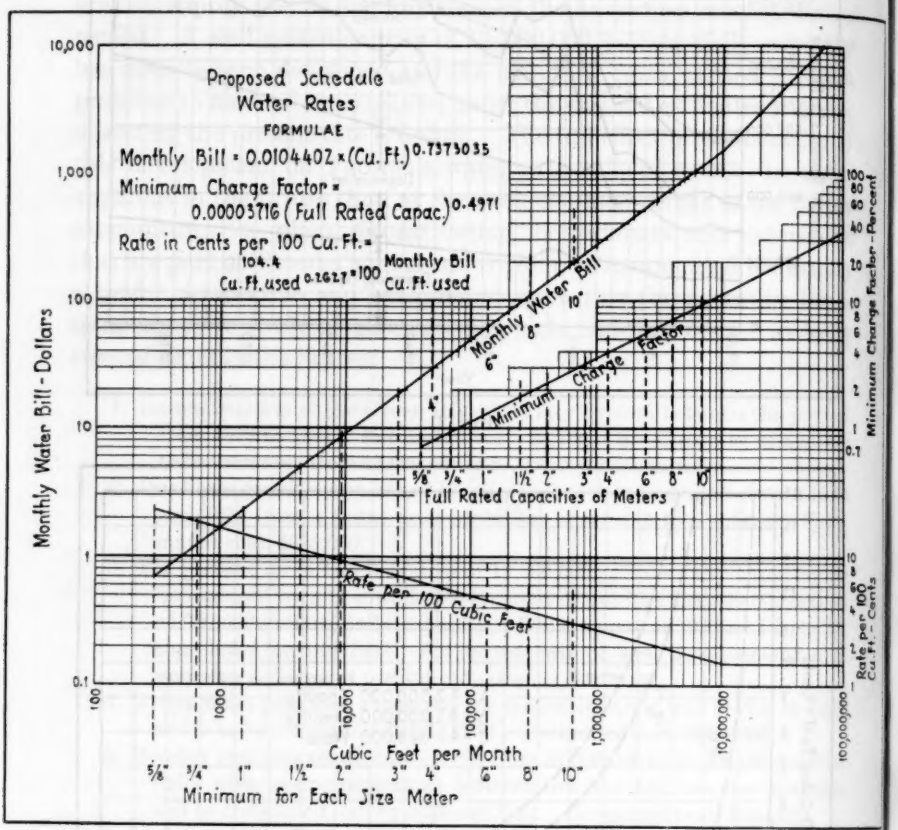
Proposed Schedule
Water Rates
FORMULAE
Monthly Bill = 0.0104402 × (Cu. Ft.)^0.7373035
Minimum Charge Factor =
0.00003716 (Full Rated Capac.)^0.4971
Rate in Cents per 100 Cu. Ft. =
104.4 / Cu. Ft. used^0.2627 + 100 Monthly Bill / Cu. Ft. used
Monthly Water Bill - Dollars
Monthly Water Bill
Minimum Charge Factor
Minimum Charge Factor - Percent
Rate per 100 Cubic Feet
Rate per 100 Cu. Ft. - Cents
5/8" 3/4" 1" 1½" 2" 3" 4" 6" 8" 10"
Full Rated Capacities of Meters
Cubic Feet per Month
Minimum for Each Size Meter

FIG. 3

with large amounts of capital invested for many years in idle plant capacity. The most surprising result brought out by the well development is that a complete auxiliary well system can be installed under conditions existing in Tacoma, at a cost less than one-sixth of the present gravity system. The effect of this program on future water rates is self-evident.

WATER RATES

Figure 3 illustrates graphically a study that the Tacoma Water Department has made of a proposed water rate for the City of Tacoma to supersede the present rate which in some respects is not entirely satisfactory. The present meter rate is made up of a ready-to-serve charge and a charge for water furnished as follows:

SIZE OF METER	SERVICE CHARGE PER MONTH
inches	*dollars*
$\frac{5}{8}$	0.50
$\frac{3}{4}$	0.75
1	1.50
$1\frac{1}{2}$	3.00
2	5.00
3	10.00
4	15.00
6	30.00
8	50.00
10	90.00
12	130.00

The charge for water consumed is 10 cents per 100 cubic feet for the first 5,000 cubic feet; 6 cents per 100 cubic feet for the next 25,000 cubic feet; and 4 cents per 100 cubic feet for all consumptions over 30,000 cubic feet.

The ready-to-serve charge covers a portion of the cost of furnishing water based on the capacity of the meter and the cost of providing reserve capacity at all times, regardless of the amount of the consumption. The service charge produces approximately one-third of the meter revenue in Tacoma and helps, therefore, to reduce the unit rate on all water consumed. In reference to the application of the service charge, we find that the consumers invariably look on this charge as an additional charge over and above the cost of water furnished. It is for this reason the Tacoma Water Department proposes to adopt a minimum charge in lieu thereof, for which a certain quantity of water will be furnished. The rate schedule worked out in figure 3 is what might be termed the logarithmic rate scale. The equations involved establishing the slide as contemplated under the scale are given in figure 3.

The novel feature about this rate scale is the minimum charge based on a load or charge factor which is used in connection with power

rates, but which the writer has never seen applied to water rates. For instance, it was assumed that a large consumer requiring approximately 6,000,000 to 8,000,000 gallons of water per day should guarantee to the Department an income of not less than $1,500 per month, or $18,000 per annum in order to protect the necessary plant investment as far as possible. For this minimum charge the consumer would be entitled to 75,000,000 gallons per month, which is at the rate of $20 per million gallons, or 1½ cents per 100 cubic feet. This is the lowest rate now quoted by the City of Tacoma. On the other end of the scale it was assumed that a minimum revenue of 70 cents per month was necessary from a ¾-inch service with ⅝-inch meter and that 300 cubic feet of water would be furnished for this minimum charge. The slide between these two extremes in the rate represents a straight line on the logarithmic scale of figure 3.

The minimum charge factors for different sizes of meters represent the coefficients to be applied to the maximum capacities of the respective sizes of meters, assuming approximately a 5 pound pressure drop in the meter. The minimum monthly charge for each size of meter is then established on the basis of the regular scale rate applied to this minimum quantity of water so determined. The assumption for the minimum charge requirements for the smaller meters are based somewhat on Allen Hazen's Table of Load Factors in his book on "Meter Rates" and for the large meters these charges were based on an arbitrary minimum revenue which it was felt was necessary to protect the investment of the Water Department.

From a theoretical standpoint, this scale is simple enough, but its practical application is not quite so simple as it looks. The diagram would either have to be plotted on a large scale logarithmic paper or bills would have to be computed with a log-log slide rule. Either method would be difficult to explain to the consumer.

The Water Department has already computed a table from which all bills for consumptions from 0 to 10,000,000 cubic feet can be read directly. This, the writer feels, is the simplest method for making this rate scale practical in its application.

The writer herewith wishes to acknowledge his indebtedness to Lothrop Crosby, Hydraulic Engineer in the Water Department and B. P. Thomas, Assistant Superintendent in the same Department, for their assistance in the preparation of estimates and the rate diagram, which are part of this paper.

CONQUERING THE PERQUIMANS RIVER WATER[1]

By R. W. Luther[2]

Hertford, like most towns of eastern North Carolina, is very old and has enjoyed a slow but steady growth. Being located in the Dismal Swamp Region, the water table is a few inches from the surface of the ground, and the population for years has been largely utilizing for drinking water the short driven, pipe pitcher pump so commonly seen in that section. It is literally possible to drive a pipe down anywhere and get water. Therefore, the people have not been greatly excited as to the water supply, regarding it largely as a source for the fire department, industries, and the flushing of toilets—leaving the more important function, that is, drinking water, to the back yard pumps.

In quantities sufficient for municipal needs only surface stream water is available, since the deep seated ground supplies are too salty for human consumption. After vainly trying to get an acceptable deep seated supply the town decided to build a filter plant to treat the dark river water. Pending the construction of the plant this water was used without treatment other than chlorination.

TREATMENT OF THE PERQUIMANS RIVER WATER

Being a drainage stream for a large section of the Great Dismal Swamp the Perquimans River carries at all times the dark brown high color so common to the streams of that region. Those waters have been historically mentioned as the sweet juniper waters which were so highly prized by shipmasters in days of Blackbeard or Teach, and other famous North Carolina pirates. The reason for the high esteem in which this water was held was its great stability. It is this stability so prized by shipmasters which causes the difficulty with modern methods of treatment.

When starting the plant it was found that the remarkable stability of the colloidal coloring matter prevented the success of the usual methods of coagulation and filtration. However, at that time,

[1] Presented before the North Carolina Section meeting, October 14, 1930.

[2] Plant Superintendent, Elizabeth City, N. C.

simple treatment with alum and an alkali was the only commercially known method of coagulation. This was adopted with partial success and continued until January, 1930. The plant effluent during this period contained as high as 11 or 12 p.p.m. precipitated or unprecipitated alum and the clear water well served simply as a secondary settling basin. This phenomenon is a very common one with such waters and was a cause of the difficulty encountered at Elizabeth City, prior to January, 1928.

Through the foresight and public spiritedness of Mayor Stokes and the Board of Commissioners the town has, this year, adopted the modern methods of the treatment of highly colored swamp water under technical supervision. With the substitution of a ferric coagulant for alum and following it up by a second stage precipitation with a caustic coagulant we have been able to produce an iron and alumina free water which is also free from color and has found favor with the citizens.

The change of treatment is not alone responsible for the improvement of the quality of the water. In fact, we found that the simple change of the treatment would not produce the desired results. Lack of agitation and settling time were two very important factors overlooked in the design of the plant.

We found that, with the available space in the mixing chamber, we had only enough retention for the first or ferric coagulation to be completed, and that we did not have sufficient time for the second stage coagulation. We also found that the retention period in the coagulation basin was insufficient and that a great deal of unsettled floc was passing into the filter, making the filter runs incredibly short and putting a very heavy load on the filter.

It was decided that, by simply removing the end of the coagulation basin and extending it and the mixing chamber 12 feet, a very satisfactory coagulation basin and mixing chamber could be had. This mixing chamber consists only of a trough 2 feet by 12 feet by 24 feet with over and under baffles.

By utilizing at odd times available labor already employed by the town and hiring only a very few extra men, including only one carpenter, the addition to the basin was built at a cost of $16.90 a cubic yard of concrete. We regard this as a very satisfactory unit price.

Upon putting the new unit of basins into service we found that at times we still had some slight evidences of the filter passing floc. Upon physical analysis of the sand by the State Board of Health,

it was found to have a uniformity coefficient of 3.46 and an effective size of 0.159, which of course did not conform with the specifications of good filter sand, which for North Carolina have been fixed at an effective size between 0.35 and 0.45 mm. and a uniformity coefficient to be not greater than 1.7.

Each grain of sand had been covered with a coating of organic matter which had decreased the efficiency of the sand bed. This sand was found to be 0.20 percent dust. The dust consisted of this organic covering which was peeling off as the sand was dried. This coating can be removed by treating with a strong caustic solution. After a sample of the sand was thus treated, it was found to have an effective size of 0.49 and a uniformity coefficient of 1.2, which of course would make a more efficient filter sand. However, a new sand with an effective size of 0.38 and a uniformity coefficient of 1.52 was placed in the filter and since then we have had no trouble with the floc passing the filter.

As the water has a very high organic content we expect to have this new sand become coated similar to the old. However, we plan to treat the sand periodically with caustic and thereby keep it continuously in good shape. This treatment may be accomplished by putting lye, or caustic, in water lowered within a few inches of the sand. The rewash valve is then opened and the strong caustic solution allowed to go down through the sand. This solution is then pushed back up through the sand with wash water and allowed to stay in the sand bed as long as practicable within a twenty-four-hour limit.

Because of the large amount of residual alum and floc that the plant effluent has heretofore contained and the high organic content of the water we have been troubled by a coating of these in the mains. Any slight disturbance of the mains causing a breaking loose of this coating resulted in water delivered to the customers in a very undesirable condition. The water at such times was literally full of floc particles. However, by frequent flushing we have been able to remove this objectionable state and are experiencing no further trouble.

Method of chemical treatment

For the preparation of chlorinated copperas we feed the dry commercial sugar of copperas continuously, at a constant rate from a Type O, Wallace and Tiernan dry feeder. This copperas is fed into a cast iron pot wherein a minimum quantity of solution water is

constantly flowing, thus producing a discharge from the solution pot containing a constant amount of copperas in aqueous solution with respect to time. Chlorine, in the form of chlorine water, from the discharge of a solution type chlorinator, is now merged with the copperas solution in ratio of 1 part chlorine to each 7.8 parts copperas by dry weight. The complete reaction is:

$$6\ FeSO_4 \cdot 7H_2O + 3Cl_2 \rightarrow Fe_2(SO_4)_3 + 2FeCl + 42H_2O\ .$$

Evidence of complete chlorination is obtained by spot tests for ferrous iron with potassium ferricyanide.

The object of chlorination in this case is to effect complete conversion of the iron from the bivalent to trivalent state, for bivalent iron has no affinity for coloring matter, while trivalent is in itself a powerful coagulating agent for the negatively charged colloidal particles which constitute the principal objectionable constituents of our raw supply.

This ferric solution is introduced into the raw water so as to provide the minimum amount of coagulant necessary to produce well formed floc particles. Coagulation is improved by the addition of lime, if necessary, to bring the water to the iso-electric point of the Fe^{+++} plus color particles. The water filtered at this stage will contain considerable floc which is too small to be settled out or retained on the filter bed and is also at an abnormally low pH value, being from 3.2 to 4.0 depending upon the temperature, rain water dilution, etc. To correct this objectionable state we now add a caustic coagulant to a pH where the floc particles are well formed and the supernatant has a clear sparkling appearance. This pH again varies with physical factors and we have found that a satisfactory water may be had at a pH of from 5.6 to 6.0.

It is essential that these coagulants be added in the correct sequence and time intervals, as the addition of the caustic coagulant before the formation of floc in the first stage will cause a very undesirable condition. The resultant water will have a very much lower pH value than if the chemicals are added as described above. In fact, it is difficult to get any increase in pH value by the addition of the caustic coagulant, unless the first stage is complete for the addition of the second. A plausible explanation for this phenomenon is that the acid groups of chlorinated copperas also assist materially with coagulation and if agitation and time are provided will be removed from the solution by the first stage floc precipitation, thus

not interfering with the second coagulation by neutralization of the caustic contained therein. The caustic then apparently raises the pH of the water to the point described above.

For the second stage we have been using commercial dry sodium aluminate. After the water has gone through these two stages of coagulation it is settled and filtered in the usual manner and then stored for use.

Laboratory control

Our laboratory control includes the standard determinations recommended by the North Carolina State Board of Health, for water plants, with special emphasis being placed on pH values at different stages of treatment. Periodic chloride determinations to determine danger of salt water backing up the river from the Sound, and very careful jar tests with the two stages treatment constitute the principal variations from the routine laboratory practice in North Carolina.

CONCLUSIONS

1. The two-stage treatment employing chlorinated copperas as described by Hedgepeth and Olsen at Elizabeth City[3] has proven the satisfactory method for producing esthetically acceptable water from the Perquimans River water.

2. Technical control of water purification as practiced in the larger North Carolina plants has apparently proven entirely satisfactory at Hertford.

3. By a combination of the above two items we have for the past nine months been slowly, but surely, placing the public water supply of Hertford in a position where the average citizen will depend upon it for his drinking water.

4. The design of water plants should be controlled largely by careful consideration of the peculiarities of the water to be treated and not be controlled by stock plans as this plant was constructed and operated for nine years, producing during that time water which was regarded with suspicion by the citizens.

Grateful acknowledgment is made to the North Carolina State Board of Health and to the Technical Service Department of the Pennsylvania Salt Company for their advice and assistance during these past ten months of experimentation and readjustment.

[3] Chlorinated Copperas a Novel Coagulant. Jour. Amer. W. W. Assoc., October, 1928.

SWIMMING POOLS AND WATER DISTRIBUTION SYSTEMS[1]

By Carl A. Hechmer[2]

Although a growing wealth of data is available on swimming pool design, construction, and operation, little has been said of the relation of the swimming pool to the water distribution system, which supplies the new water, and the burdens which each place on the other. The ability of the water system to supply an unlimited amount of water for refilling the pool and the cost thereof will govern as to whether the pool should use the fill and draw method or recirculation with independent purification methods. The latter is the generally accepted practice, being more satisfactory, both because the purity of the water may be controlled at the pool by its operators, to take care of varying bathing loads and, except in isolated cases, it is more economical. The cost of recirculation, pumping, and purification is very small, being as low as one cent per thousand gallons, which is far under most municipal rates for water, at the Chevy Chase Swimming Pool operating under the writer's supervision.[3]

EFFECT ON DISTRIBUTION SYSTEM DESIGN

While a distribution system can be economically designed to take care of industrial, domestic, and fire flow requirements, all of which may be anticipated with reasonable accuracy by the designing engineer, it is usually impossible to foresee where a swimming pool may be erected on the system and to provide for this large consumption of water. The growing popularity, however, of swimming pools in schools, hotels, apartment houses and recreational centers, should be considered, within practical limits, in distribution system design and perhaps a greater safety factor used in estimating water requirements. Of increasing importance to the designer is comprehensive

[1] Presented before the 4-States Section Meeting, March 31, 1931.

[2] Department Engineer, Washington Suburban Sanitary District, Hyattsville, Md.

[3] C. A. Hechmer: "Can a Public Pool be Safe?" Municipal Sanitation, 1: 3, 138.

city-wide zoning as it relates to setting aside recreational areas where public swimming pools would be placed and to the definite location of apartment house and hotel areas. Thus the sections where the large demand of the swimming pool is fixed.

Larger feed mains and better gridironing in the distribution system than would be ordinarily necessary must be provided by the water department in order to furnish water in sufficient volume to permit satisfactory operation of the swimming pool. If designed to take care of the maximum possible demand of the pool which, in the case of outdoor pools, will occur in the summer when the water system is already taxed to its maximum capacity, these large mains may result in a heavy financial loss when, in the winter, reduced consumption results in the revenue falling far below the carrying charges on the investment. An over-designed distribution system also holds water for an unnecessarily long period before it reaches the consumer, thus encouraging after growths and tastes. Large outdoor swimming pools with capacities of one million gallons or more are not uncommon and are generally built in suburban sections where real estate is cheaper and other recreational features may be added. The water distribution systems in the suburban areas are not as well supported as those in the center of the city and unless the pool is located on a feeder main trouble will surely occur. If the water supply to a swimming pool is to be limited to a small size connection or to a certain maximum rate of draft, the pool must be provided with a storage tank to accumulate water so it will be available at the required rate when needed and operation methods must be confined to the capacity of this storage.

The additional cost of larger feed mains, if these are installed, cannot, however, be charged to the entire system with a resulting higher water rate or tax to the consumer. Within certain limits the cost of the production of the water will be lessened due to increased delivery, but the greater investment in pumping equipment and distribution mains will more than offset any such saving. The application of a demand charge based on hourly or daily use of water, such as is used in electric power schedules, will go far toward charging the additional cost to the customers causing it. This will also cause the swimming pool designer to provide against high rates of draft, but will not endanger the satisfactory operation of the pool. Should accident or condition of the pool water necessitate the draining of a pool during the busy season, two or three days delay in refilling might result in the

loss of considerable revenue to the pool owners, but the payment of a monthly demand charge would be comparatively small.

BACKWASHING FILTERS

Where filters are used to purify the water in a recirculating system the source and the amount of water necessary for backwashing the filters are questions which have caused considerable discussion. If the general practice as exercised in the municipal filtration plant is employed and clean water is used, it must be drawn directly from the distribution system or a wash water tank provided which will allow a slow rate of draft from the distribution system yet provide the maximum rate for washing filters when needed. Although sectional wash is generally used in filters of the swimming pool type, most manufacturers advise that after each section is washed, the entire filter be washed as a whole for a short time. To take such a large volume of water from the ordinary water distribution system would result in pressure drops in the vicinity of the pool, endanger fire protection, and the resultant high velocities in the mains would stir up sediment and result in complaints from water consumers in the neighborhood. The unrestricted use of control valves by inexperienced persons, who would open and close them too quickly, would result in severe water hammer on the distribution system and cause broken mains and plumbing fixtures.

It is common practice to use water from the swimming pool to wash filters and make up the loss with new water at a slow rate afterward. The circulating pump is usually designed to provide a sufficient quantity of water at the low washing head to wash the filter effectively. Since the circulating pump takes suction from the polluted end of the pool the filter is in reality being washed with polluted instead of clean water. This objection has been overcome at the Chevy Chase pool by providing a two-way valve on the chlorine solution line, allowing the diversion of the chlorine solution to the pump suction when the filter is being washed and to the filter effluent when the filter is in normal operation. The chlorine dose is doubled when being applied to the water for filter washing. This results in a practically sterile water for washing purposes without affecting the water distribution system.

CROSS CONNECTIONS

The regulation or prohibition of cross-connections between the polluted pool water and the municipal supply, while primarily the duty of the health department, should also receive the careful consideration of the water department. Pipe lines for filling the pool, adding daily make-up water, supplying chemical feed apparatus, especially chlorine machines and pot-type alum applicators, and primers for circulating pumps or water seals to supply clean water to the stuffing boxes or circulating pumps should be carefully installed and protected to prevent cross-connections. Supply pipes for filling the pool should always have a free outlet above the pool water, as an outlet below the surface of the water forms a cross-connection which may have serious results. All of the foregoing possible cross-connections, should the water supply main be shut down and drained for repairs while the pool is filling or in operation, would permit the polluted pool water to enter the water mains unless proper protective measures were taken in design and operation. The washing of filters with water direct from the water distribution system presents a serious cross-connection problem second only in importance to the under water inlet pipe for adding new water to the pool, which was common practice in swimming pool construction before the advent of health department control. If the control valves are not closed properly and pressure on the distribution system side falls below the pressure on the filters, polluted water will escape into the mains. If the local laws compel the use of new water for filter washing a wash water tank with inlet pipe above the overflow must be provided.

SIZES OF POOL SERVICES

Answers to a questionnaire, sent to 15 representative cities in the east and middle west relative to their practice in providing swimming pools with water service, disclosed wide variations governed generally by local conditions. On the question of maximum size of service pipe for filling the pool, two cities do not allow connections over 4-inch; four allow one size less than the main in the street, i.e., a 4-inch connection is permitted off a 6-inch main, a 6-inch off an 8-inch and so on; one restricted the size of feed pipe to two-thirds the feed main; one limited the connection size to allow a rate which would fill the pool in twelve hours; two allow not over 6-inch connections and five cities install whatever size is applied for, no limit being placed on the size of connection. Five cities control the rate of draft for filling

the pool by different means to effect minimum interference with the water distribution system, while the remaining ten allow filling at any time and at any rate of flow possible with the connection installed. With one exception all have definite regulations relative to control and prohibition of cross-connection; the remaining one is now preparing an ordinance to force indirect connections in all swimming pools. Five of the cities allow washing of filters direct from the water distribution system, thus effecting a bad cross-connection, although four of them have cross-connection regulations relative to fill pipes and other pool appliances. No attempt is made by any of the fifteen cities to control the daily use of make-up water and wash water for the filters as these loads are generally for a short period only or the rate of draft is very low.

The artificial swimming pool is growing in popularity by leaps and bounds, presenting a new problem to the water-works engineer. Manufacturers are ever alert to increase the sale of their products and to encourage new uses for them. Likewise the water-works engineer should aid these new fields for the sale of his product by providing good engineering judgment and as satisfactory service as possible within reasonable cost.

FEEDWATER TREATMENT ON THE ATLANTIC COAST LINE RAILROAD[1]

By O. L. Anderson[2]

Some twenty-five years ago, not so long after the Plant System of Railroads, traversing the states of Florida, Georgia and Alabama, was absorbed by the Atlantic Coast Line, it soon became evident to the management of the company that for economical operation of locomotives and steam boilers in general it would be necessary to adopt some form of feedwater treatment to protect such boilers. After due consideration was given to this important matter, the type of treatment selected was that known as the lime and soda ash process. The treatment plants installed were of the continuous type and were built by the American Water Softener Company of Philadelphia. A number of these plants were installed along the lines of the road in the state of Florida. The locations of such plants were selected so as to take in the points where the water gave the greatest amount of trouble, special attention being given to the larger terminals where the water was bad and large quantities of it being consumed, much to the detriment of the equipment.

The treatment plants as described above consist of a settling tank, an automatic device for proportioning the chemicals used to the amount of raw water passing through the plant, the chemicals having previously been mixed and properly proportioned as to amounts of lime, soda ash and sodium aluminate, to soften the water effectively. After the chemicals and the raw water are mixed the water is given about four hours in which to settle out the precipitate, after which it passes through an excelsior filter and flows by gravity to the wayside tank or storage tank, where it is held in readiness for locomotive use and other steam boilers as well. When the softening plant is in operation the entire body of water within is slowly moving. This condition unfortunately retards the settling process. However, a very serviceable water may be produced for steam boiler use if the

[1] Presented before the Florida Section meeting, April 10, 1930.

[2] Supervisor, Water Softener Plants, Atlantic Coast Line Railroad, Jacksonville, Fla.

velocity of the water in the settling tank does not exceed 8 or 9 feet per hour.

Chemicals used for treating water on the Atlantic Coast Line Railroad are hydrated lime, 58 percent light soda ash and number two sodium aluminate, the latter a coagulant which has come into quite general use in railroad water service during the past five years. These chemicals when properly proportioned, thoroughly mixed and introduced in the raw water and given time for chemical reaction, will in most cases reduce the incrusting solids to 1.5 or 2 grains per gallon. The use of such water for locomotive boiler feed has been found to prolong the life of boiler flues by a very considerable period of time. However, no records were available to show the exact percentage of increased life that could be charged to treated water.

A large percentage of water used on the Atlantic Coast Line today, especially in the state of Florida, is derived from wells, ranging in depth from 40 to 900 feet. The incrusting solids, largely calcium and magnesia, range from a few grains per gallon to 50 grains per gallon. The total solids, however, in some supplies will reach 150 grains per gallon. Such supplies as the latter usually contain large quantities of salt which is very objectionable, especially in locomotive boilers, giving rise to serious trouble from foaming. Such supplies as last referred to are avoided whenever it is possible to obtain a better supply at a reasonable cost.

In the chemical treatment of water in railroad service, as in most other lines of work, unless adequate supervision is maintained satisfactory results cannot be had. In order to check effectively the operation of treatment plants on this road where they are located at widely separated points, sample boxes, each fitted with two containers, are provided and once each week the operator in charge of each plant is required to fill one container with treated water and the other with raw water from his station. These samples are shipped to Jacksonville, the samples are there examined and if these tests show that the water is not receiving the proper treatment the operator is notified and, if necessary, the chemical formula is changed, the raw water sample referred to is used in determining the new formula and the data are kept as a record to show the changes taking place in the various supplies throughout the year. If a sample of water should show an excessive hardness or a hardness of more than 6 grains per gallon the operator is called on to make an explanation. In addition to the samples shipped in for examination, the supervising officer spends consider-

able time on the road, visiting the various treatment plants as often as time will permit. There is no stated time for these inspections and the operator soon learns that in order to have a good record it is essential that he keep the plant in good condition and operating satisfactorily as nearly as possible at all times.

At Jacksonville Shops the largest treatment plant on the system is located, its capacity being 30,000 gallons per hour. The water supply at this point is derived from two artesian wells some 800 feet deep. The incrusting solids in this water will average about 18 grains per gallon the year round. The average daily consumption of treated water at this terminal is about 350,000 gallons. In reducing the incrusting solids in the Jacksonville water from 18 to 2 grains per gallon, it will be found that 800 pounds of scale are removed from the feedwater daily, 24,000 pounds per month and, in a year's time, 288,000 pounds or 144 tons, almost three car loads, a large percentage of which, if raw water were used, would find a lodging place in the various steam boilers.

It has been determined by research work and by conservative practice and it is generally accepted by railroad water service engineers, that for every pound of scale remaining in the feedwater of steam locomotives, a cost of thirteen cents is added to the operating expenses. Assuming this figure is correct, by simple multiplication we arrive at the figure of $37,440 representing the gross saving for one year at the Jacksonville plant alone. The total cost of operating the treatment plant at this point is conservatively estimated at not over $7500 per year. Deducting this amount from the former figure, we get $29,940 representing the net saving for one year, brought about by the use of treated water.

While much good has been accomplished on this road by the use of the lime and soda ash softening plants, they nevertheless have their disadvantages. Chief among these is the outlay of capital necessary for the erecting of the plants. At many points the character of the water may be such as to suggest a complete treatment plant, but the quantity of water used may not be sufficient to justify an expenditure equal to the initial cost of a softener. In an effort to solve such problems, this road has during the past few years experimented with a number of different boiler compounds found on the market. Some of these have been found to be good, some fair and some indifferent. Experience in this field has taught, as in most other lines, that it is usually best to deal with the well-established and reputable concerns handling this class of business.

During the past twelve months this road has been experimenting with internal boiler treatment, using soda ash and sodium aluminate. These two chemicals are mixed together in water and are usually introduced in the boiler by way of the injector. A sufficient quantity of the chemicals are used to maintain practically a zero hardness in the boiler water. Such a condition probably could be attained by the use of soda ash alone, but if the boiler is subject to heavy and sudden demands for steam there would be grave danger of priming and foaming. The use of sodium aluminate through its coagulating properties seems to eliminate these troubles successfully. This class of treatment up to the present time has been confined almost entirely to stationary power plants and the results obtained in removing and preventing scale as well as some pitting and corrosion have been so favorable as to justify further experiments with the possibility of extending this class of treatment to locomotives where the work is not too heavy and the quantity of water used is small.

STORAGE TANKS[1]

By A. W. Hebbring[2]

Storage at an elevation is one of the oldest methods of providing water for the use of man. Initially water was stored in a reservoir on some near elevation, and this method still prevails where a city is so fortunately situated as to have sufficient natural elevation within or near its limits. Where this is lacking it has been necessary to provide a substitute by erecting a tower. The first towers were made of stone or brick, later ones of wood, and now practically all are built of steel.

Elevated tanks were first built not only to provide storage, but also to provide the necessary pressure. Subsequently it was found that it was cheaper and more efficient to install smaller pumps and to pump into a large elevated tank than to install large pumps and pump directly into the mains. With an elevated tank one may not only provide more uniform pressure, but may do the pumping at a time when there is not such a great demand for power, and may in many cases secure, in this way, a better rate on electricity.

While the pumps built at the present time are most efficient and durable, there is always the danger of breakage to the pump or power line, which would seriously cripple the water service. The installation of an elevated storage tank of sufficient size would take care of the water service while repairs to the pumps or power line were being made. In the most serious cases the water stored in the elevated tank would at least provide fire protection.

Machinery depreciates much faster than steel water tanks, and new designs and improvements are constantly being brought out. In many cases the pumps are out of date in a few years, but the present type of elevated steel water tanks has been in use for a number of years and doubtless will prevail for a long time. Of course, a number of refinements in design have been developed, but the main design has not been changed materially.

In the past few years there has been a constantly growing demand

[1] Presented before the Wisconsin Section meeting, August 22, 1930.

[2] Superintendent, Water Works, Wauwatosa, Wis.

for large elevated storage tanks with a capacity of from 500,000 to 2,000,000 gallons, and this demand has been brought about by the rapid growth of cities and towns. No matter how far-sighted the engineers were who planned the original water system, they were unable to visualize the rapid growth of many cities, and the problem that confronts a number of cities is how to provide sufficient water at a useful pressure in the suburban districts. In a number of cases the city has ample water supply and pumps sufficient to take care of the normal daily consumption, but could not take care of the maximum consumption, and it has been necessary to limit the sprinkling hours and in other ways cut down the consumption.

Detroit, Michigan, was the first large city to undertake to solve the problem, and after careful consideration of the cost, efficiency and maintenance, they decided upon a plan of installing 12 tanks of 1,000,000 to 2,000,000 gallons capacity, at elevations suitable to the locality, to be installed in the outlying districts. These tanks ride on the line, and cut in when the consumption exceeds the pumping capacity during peak loads, and in this way provide plenty of water at sufficient pressure to supply the outlying districts.

WAUWATOSA SYSTEM

In our own city of Wauwatosa, a residential city, we had a similar case, except, of course, on a smaller scale. We secure our water from four deep wells equipped with Layne deep well turbine pumps, all of which are controlled automatically; and one deep well equipped with airline and compressor under manual control. The supply is ample for average daily consumption, but our system is subjected to high peak requirements, particularly during the summer months in hot dry weather. Our problem has been to meet most efficiently this abnormal demand. Installing additional wells with new pumps and increasing our mains was one solution, but after careful consideration we decided upon elevated storage, installing in 1927 a 500,000 gallon elevated tank, and in 1928 a 1,000,000 gallon elevated tank built by the Pittsburgh-Des Moines Steel Company. These tanks enable us to take care of our maximum consumption, and the storage is sufficient at present to allow us to do our pumping during the off peak on the power line. We have also provided ground storage at three wells in the form of a 1,000,000 gallon steel tank and a 500,000 gallon concrete tank adjacent to two of the wells and a 200,000 gallon steel tank at another. The deep well pumps discharge into these tanks, the water striking a baffle placed above the maximum water

level for the purpose of aeration. The elevated tanks previously mentioned are likewise provided with connections direct to the deep well pumps to permit aerating the water before it enters the system.

Certain waters contain gases in some form, usually sulphur, and are easily removed by proper aeration, whereas if pumped directly into the system the emanating gases might be found objectionable when water is drawn for domestic use.

Aeration likewise tends to oxidize iron, found in some waters in relatively large amounts. After oxidization the iron, if undisturbed, will be precipitated, and can be removed by occasionally flushing the tank.

Both factors prompted us to aerate the water and likewise were determining factors in locating the tanks, inasmuch as it was necessary to place them at the wells or lay separate mains to them to provide aeration.

In case a large available water supply, such as a lake or river, is at hand, the increased water consumption can be cared for by installing additional pumps; but these call for larger mains, and larger mains are very expensive to install, especially in busy city streets full of street car tracks, sewers, telephone lines, etc.

The better and cheaper way is to use the present pumping plant and mains, and to install an elevated storage tank of sufficient size to provide for the maximum consumption period. It will also provide a more uniform pressure on your whole system.

SUMMARY

1. Storage of water at an elevation makes use of Nature's force of gravity.

2. It provides water at more uniform pressure.

3. It permits the operation of pumps during the off peak load on the power line.

4. It permits the use of present water supply mains and pumping equipment by providing storage to take care of maximum consumption.

5. It permits the pumping equipment to run at most efficient rate instead of reducing speed as in case of direct pumping.

6. It provides storage to take care of accidents or trouble with pumping equipment or power lines.

7. It can be installed without interfering with present equipment.

8. The depreciation and upkeep are small.

9. It is the answer to the problem now confronting many towns and cities.

THE CEDAR RIVER WATER SUPPLY[1]

By C. O. Bates[2]

A matter of importance as we begin to improve our water supply would be a better knowledge of the source and quality of the supply. We are to make more extensive use of the Cedar Rapids municipal water plant and obtain a far better quality of water than we have had heretofore. We have decided to use the Cedar River as our source of supply and the whole valley of the Cedar River becomes at once a matter of great interest to us, and will in the future have greater significance than it has had at any time in the past. Many cities patrol the whole river valley from which they get their supply. This is true of Columbus, Ohio, and Baltimore, Maryland, and other cities. We cannot hope to do this for the Cedar River at the present time, yet it may be a worthy ambition for future realization. However, we can make use of a study of the Cedar River valley with reference to its drainage, the kind of soil and rock over which it passes, the amount of rainfall, the area in cultivation, the kind of agricultural products that are produced here, the number of industrial plants and the kind of household waste dumped into the streams.

Since Cedar Rapids has taken this forward step every Waltonian League, every Conservation Club, and every other civic club in our state assumed a new view of the Cedar River. Not only fish and game are to be protected, but human beings are to be satisfied with a more wholesome and far more useful quality of water. Much interest has already been manifested in this direction, but there is need of actual work in preventing polution of our streams.

DESCRIPTION OF CEDAR RIVER

The Cedar River rises in the marshy glacial drifts of southwestern Minnesota, Dodge county, near the town of Hayfield. That point is 1,310 feet above sea level. It falls 740 feet in flowing a distance of 300 miles where it joins the Iowa river at Columbus Junction. It drains an area of 7,870 square miles, 6,870 square miles of which lie

[1] Presented before the Missouri Valley Section meeting, November 5, 1930.

[2] City Chemist, Water Department, Cedar Rapids, Iowa.

above Cedar Rapids. The mean elevation of the water at the 3rd avenue bridge at Cedar Rapids is 705. This is an average fall of a little more than $2\frac{3}{4}$ feet per mile, giving it a reasonably good velocity.

The river bed is composed of rock and gravel, is free from vegetation and practically permanent, making it one of the best river beds in the Mississippi valley. The greater part of the valley of the Cedar River is a part of the famous corn-belt region of North America. The valley extends about 25 miles north into the state of Minnesota. The direction of this and all the other six larger valleys of the state is from northwest to southeast. West of the divide between the Mississippi and the Missouri rivers all the rivers which are small extend from the northeast to southwest. The greatest width of the Cedar valley is about 50 miles near the Minnesota state line, and maintains that width nearly 100 miles in a southerly direction. The surface of the country in the Cedar River valley is a general, undulating prairie, level in some sections with a moderate amount of timber fringed with brush. Peat beds and marshes are found in some of the northern counties of Iowa. The section drained by the Cedar River has a drift soil, largely a sandy or gravel loam. Underlying this is a firm, compact limestone of Devonian formation. The stream and its tributaries are said to have more numerous and extensive exposures of rocks along the valleys than any of the other Iowa rivers, giving it the natural means of self purification. The exposures usually appear as rocky banks rising to a height of 20 or 30 feet in some places. The drift is well supplied with springs, the well known springs at Marion, and the McLeod spring at Cedar Rapids are typical.

The following lakes are found in this watershed: in Minnesota, the Freeborn Lake, Albert Lea Lake, Upper Twin Lake, Lower Twin Lake, Bear Lake and Pickeral Lake; in Iowa, Clear Lake, Harmon Lake, Silver Lake, Bear Lake, Rice Lake, Geneva Lake, Leeds Lake. In all there are more than 14 square miles of Lake surface.

According to the government gauge at Cedar Rapids the average discharge is 3,300 cubic feet per second, more than 2 billion gallons per day. The 5 million that we now use daily is only about one-fourth of 1 percent of the average flow. April 1, 1912, and March, 1917, there was on each date a maximum discharge of 5,400 cubic feet. On March 18, 1929, there occurred the greatest discharge on record, namely 64,000 cubic feet per second. The minimum discharge occurred December, 1916, namely, a little less than 400 cubic feet per second.

The average rainfall per annum in this watershed is 32 inches. About 20 percent of the water passes off through the channel of the river.

Two-thirds of the people of the United States of necessity take their water supply from surface water, rivers and lakes. This has been brought about by the shifting of our population from the farms in the country to the industries of the cities. In a general way it may be said that cities of 50,000 or over have to get their supply from surface water. Deep wells have failed in so many instances, and are failing yet, that it renders such a source uncertain as well as expensive.

The question directly before us in the quality of water in the Cedar River. The analysis of water shows that it can be rendered reasonably soft by eliminating the carbonate hardness, or so-called temporary hardness. This is being done in an inexpensive way by the use of lime and a small amount of alum. We are exceedingly fortunate in that the Cedar River does not have the two most objectional kinds of hardness, namely, bicarbonate of iron and sulphate hardness. We, therefore, have to deal directly with the elimination of primarily two chemical compounds, namely, calcium bicarbonate commonly known as limestone and magnesium bicarbonate commonly known as magnesite.

The high cost of keeping clean is a subject that is beginning to receive consideration. Articles under this caption have appeared recently in the *American* and also in the *Literary Digest*. I quote from the spirit and thought presented by Mr. Charles P. Hoover, chemist in charge of water softening and purification works at Columbus, Ohio. I wish every woman in every club in the United States could read his interesting article on Municipal Water Softening. His theme is the importance of softening water at a central source of supply rather than in thousands of homes, wherein he shows that such a plan is economically sound.

It is estimated that the high cost of keeping a family in moderate circumstances clean is 10 percent of every dollar. A San Francisco Hotel reported that the annual cost of table linen was $3,000 less when soft water was used, while the fabric was much better in appearance.

SOAP LOSSES DETERMINED EXPERIMENTALLY[3]

The amount of soap consumed and the quantity of water used for household processes, laundering, dishwashing, cleaning, washbowl activities and bathing was carefully measured for a period of one week, and calculated for a year. Two kinds of water were used, each for one week. (1) Scioto river water filtered and sterilized, but not softened. The hardness was 270 p.p.m. (16 grains per gallon). It was delivered to the home where the experiments were made in 10 gallon bottles. (2) Softened water as delivered to the consumers. The hardness averaged about 80 p.p.m. (4.7 grains per gallon). In the home where these experiments were made there were 5 people, 3 adults and 2 children. Ivory soap in bar and flake form was used. Bar soap cost 21 and flake soap 31 cents per pound. The average weight of the washings was 29 pounds per washing and was done in a vacuum type electric washer.

The water works records show that this family used the average quantity of water, about 30 gallons per day per capita. Their bill amounted to 75 cents per month. The soap was weighed before and after it was used, the soap being dried each time after being used so that the difference in weight would represent the weight actually used. The results for the week figured to one year show:

1. This family used 281 gallons of water a week for ordinary household cleaning divided as follows: laundry, 15; dishwashing, 73; cleaning, 4; bathing, 136 gallons.

2. Approximately 11.46 pounds of soap were used per week with unsoftened water or a total of 596 pounds per year.

3. Approximately 3.7 pounds of soap were used per week with Columbus city softened water or a total of 192.5 pounds per year.

4. Softened water saved this family 403.5 pounds of soap per year.

5. This soap, valued at 20 cents per pound, represents a saving of $80.70 per year and figured at 12 cents a pound, the price of cheaper laundry soaps, represents a saving of $48.42.

6. This consumer could afford to pay 5 or 6 times as much for softened water as for unsoftened water.

The investigation also disclosed the following facts:

1. One-half again as much time was needed to launder clothes in the unsoftened water as with the softened.

2. Cleanliness of clothes washed in the unsoftened water not en-

[3] From a thesis by Pauline Snyder, Ohio State University.

tirely satisfactory. Several very soiled pieces had to be rewashed and all of the clothes had to be rerinsed; and

3. The general appearance of the clothes was poor.

OUTMODED METHODS USED IN SOFTENING WATER

The heads of every home spend considerable time and money in softening water and are unaware of this in most cases. Soap has no value as a cleansing agent until it removes the hardness in the water, and produces a lather. It is deplorable in this age of scientific achievement that the housewife in so many instances wastes time, money and fabrics in operating a miniature softening plant in her own home. We no longer carry our corn to grist mills or butcher our own meat, but every woman is engaged in the antiquated and outmoded method of softening water. Cisterns were used in Cedar Rapids quite extensively at one time, but they ceased to be considered efficient long before municipal softening was known. They became foul with undesirable foreign matter and were abandoned.

The Rock Island railroad shops of Cedar Rapids soften 250,000 gallons every day for locomotives. All Cedar Rapids laundries soften their water. The Iowa Railway and Light Company softens 200,000 gallons of water per day. They do this because it is cheaper and far less trouble than using hard water.

Ordinarily the housewife in an attempt to eliminate hardness of water knows not how much hardness exists. Neither does she know the quantity of borax or softening powders needed. Neither does she know the time required for chemical action to soften the water. In a central softening plant the time required is usually from five to six hours when the correct amount of chemicals are calculated and supplied.

Laundering is only one of several items that might be discussed extensively. We mention a few:

1. The expense of additional plumbing due to encrusting solids in hard water forming scales often sufficient to close the pipes.

2. The expense of fuel to heat through scales formed in pipes. Such scale forming material often increases the coal bill from 10 to 20 cents on every dollar that would be spent should soft water be used.

THE HENDERSONVILLE WATER SUPPLY[1]

By J. H. Lampley[2]

Hendersonville, the county seat of Henderson County, is located on a plateau just west of the Blue Ridge Mountains of North Carolina, at an approximate average elevation of 2,150 feet above sea level. The normal population served by the water system is approximately 8,000, but during the summer or tourist season this increases to from 15 to 20 thousand. During the summer season each year, it entertains close to 50,000 visitors.

The original waterworks for Hendersonville, consisting of a small reservoir fed by a stream with a watershed area of approximately 2 square miles, was constructed in 1888. This proved inadequate and in 1918 it was replaced by a small filtration plant, treating water from another small stream near the city. In 1921 this supply was found to be much too small and the city set about to develop a new supply. The Gilbert C. White Company, of Durham, North Carolina, were employed as consulting engineers to study the situation and make recommendations for a new supply and to design and supervise construction. After exhaustive study, this concern recommended that Hendersonville should go to the Mills River Watershed in the National Forest for its supply. Following this recommendation, the City of Hendersonville, through its Board of Water Commissioners, handled the matter with the Agricultural Department in Washington, which Department has jurisdiction over all the National forests, with the following result. By agreement with the United States Government, through its Forestry Service branch of the Department of Agriculture, the City of Hendersonville controls 24.3 square miles of watershed area located wholly within the confines of Pisgah National Forest. Of this watershed 10.9 square miles cover the upper reaches of Bradley Creek, a tributary of South Mills River, while the remaining 13.4 square miles cover the head waters of North Mills River, all of this watershed being located in the extreme north-

[1] Presented before the North Carolina Section meeting, October 14, 1930.

[2] Manager, Board of Water Commissioners, Hendersonville, N. C.

west of Henderson County, approximately 17 miles from Hendersonville. It is all rough mountain country, heavily forested and uninhabited, except for the wild animals which live under the protection of the United States Government. Here one may find deer, bears and wild cats and numerous other wild creatures of the forest, living without fear of man. This watershed has not only the protection

TABLE 1

Analysis of Hendersonville water by the North Carolina Department of Conservation and Development

(Parts per million)

Suspended matter	2	Carbonate radicle (CO_3)	0
Total distilled solids	23.3	Bicarbonate radicle (HCO_3)	7.8
Silica (SiO_2)	8.5	Sulfate radicle (SO_4)	1.5
Iron (Fe.)	0.1	Chloride radicle (Cl)	1.3
Calcium (Ca)	1.4	Nitrate radicle (NO_3)	1.0
Magnesium (Mg)	0.8	Total hardness calculated ($CaCO_3$)	6.8
Sodium (Na)	1	Alkalinity	6.5
Potassium (K)	0.8		

Monthly water analysis

(By State Laboratory of Hygiene, North Carolina Board of Health, for January 17, 1930)

Sediment	0	B. coli in 1 cc	0
Color	0	B. coli in 10 cc	0
Turbidity	0	B. coli in 50 cc	0
Odor, cold	0	Total bacterial count per cc. at 38°C	0
Odor, hot	0		
*Alkalinity	4	Count on lactose litmus agar per cubic centimeter	0
*Chlorides	2		
Nitrites	0	Acid-producing bacteria per cubic centimeter	0
pH	6.6		

* Parts per million.

usually afforded by heavy forestation, but, in addition, is patrolled by federal officers, whose duty it is to know the purpose, movements and conduct of those who are privileged to visit the National Forest. The rainfall over this area averages 60 inches per year. This heavy rainfall, filtering its way through numerous never-failing springs, furnishes a water which is crystal clear, soft and pure. It is used without filtration. It is our proud boast that for purity and quality

our water cannot be surpassed anywhere, for domestic or industrial purposes. Bearing out this statement, we give in table 1 analyses of the Hendersonville water made by the North Carolina Department of Conservation and Development and the North Carolina Board of Health.

As a matter of interest, the essential conditions of our agreement with the Department of Agriculture, under which we control this watershed, are:

1. The city is allowed to use the area free of charge.

2. The city has the right to use any or all of the water in the area over which the National Government is vested with authority, except that no right can be granted to take water as against any riparian owner, other than the United States of America.

3. The Secretary of Agriculture reserves the right to require Hendersonville to allow any adjacent community to obtain water from this source of supply upon such terms as he considers reasonable, provided there exists a surplus over and above the needs of Hendersonville, and provided that no other source of water supply is available to said community at a reasonable cost, and provided further that these adjacent communities will be allowed to use this surplus water only so long as such surplus exists.

7. The Forest Service will continue to maintain its standard of patrol and fire prevention on the watershed.

10. Earth, stone and sand, necessary in the construction of dams, and other improvements, may be obtained without charge by the city, provided that such materials shall not be removed beyond the boundaries of the National Forest.

11. Free access across and over the watershed is retained by the Forestry Service, for the purposes of administration, protection and utilization of the National Forest Land and its resources. The city may exclude persons unauthorized by the Forest Service from its reservoir and watershed area.

16. No hunting or fishing will be allowed on the watershed.

17. The city shall save harmless and indemnify the United States, its officers, agents and employees against all costs, expenses, claims, actions or demands whatsoever, by any person whatsoever, on account of any loss, damage or injury growing out of occupation of the watersheds in accordance herewith.

25. Camping or the construction or occupation of buildings not needed by the city or the Forestry Service for the protection and

administration of said lands will not be permitted on the watershed area.

26. The city may from time to time, in coöperation with the Forest Supervisor, promulgate and enforce upon the watershed area such sanitary rules and regulations as, in its opinion, may be necessary for the protection of the purity of its water supply.

From the above it may readily be seen that Hendersonville is most fortunately situated in that it has ample watershed resources fully protected in every way at a cost of absolutely nothing.

DEVELOPMENT

In 1922 the city developed the North Fork of Mills River watershed to the following extent. An intake dam, costing $22,078.42, was built at the junction of Fletcher Creek and Big Creek, just below the point at which these two streams come together, forming the North Fork of Mills River. This intake dam is of masonry, beautiful in appearance, and impounds more than 5 million gallons of water at an elevation of 2450 feet above sea level. From this intake 17 miles of 16-inch cast iron bell and spigot pipe was laid to a new reservoir on Ewart Hill, on the edge of the city, built at an elevation of 2335 feet above sea level, the difference in elevation between the intake and the reservoir being 115 feet, allowing a gravity pipe line capacity of 2,300,000 gallons every twenty-four hours. This 16-inch pipe line was laid over some extremely rough mountainous country, crossing Mills River at thirteen different places and the French Broad River once. At each of these river crossings the pipe line was anchored in solid rock down under the bed of the stream. The total cost of this 16-inch pipe line amounted to $366,537.85. The reservoir on Ewart Hill, with a water elevation of 2335 feet above sea level, or approximately 200 feet above the average elevation of the city, holds 5 million gallons of water, approximately five days' normal supply for the city and three days' supply in the summer time when consumption is at its peak. This reservoir, including grounds and everything, represents a cost of $65,239.

The 16-inch transmission line and reservoir were completed and water was turned into the reservoir on July 4, 1923. The 16-inch line is controlled by a Simplex Venturi meter located near the intake, the measured flow through this meter being 2,320,000 gallons per day.

By 1927, for reasons hereinafter outlined, it was deemed necessary to make further development in the watershed area. Consequently,

in the spring of 1928, a concrete intake dam was built on Bradley Creek, with a water elevation of 2454 feet, this dam being smaller than the one on North Mills River and costing only $9,641.04, impounding approximately three million gallons of water. From this intake 37,900 feet of 20-inch cast iron bell and spigot pipe was laid to a junction with the 16-inch line coming from the North Mills River Intake, at a point approximately 9 miles from Hendersonville, the cost of this 20-inch pipe line being $210,352.45. This combination of 20- and 16-inch pipe, with its reduced friction, raised the delivery of the water into the Ewart Hill reservoir from 2,300,000 to 2,700,000 gallons per day. Later on, when the growth of the community demands it, it is contemplated that this 20-inch line will be extended on into the city, at which time we will have a 20-inch pipe line from Bradley Creek, with a capacity of 3,400,000 gallons per day, and a 16-inch line from North Mills River with a capacity of 2,300,000 gallons per day, or a total of 5,700,000 gallons of water for twenty-four hours.

There are several excellent natural basins where water could be impounded in tremendous quantities. For instance, at a point about three quarters of a mile below the present intake on Bradley Creek, a dam 100 feet high could be built which would flood approximately 50 acres of ground and impound nearly one billion gallons of water, with a water elevation of 2490 feet above sea level. There is a natural site for a dam at this point and it could be constructed at a minimum of cost. The same condition exists on the North Fork of Mills River, and it has been estimated that the full and complete development of our watershed would make more than 20 million gallons of water per day available to the city, or, based on present standards of computing, enough for a city of more than 200,000 people.

DISTRIBUTION SYSTEM

The main feed line for the distribution system is a 16-inch cast iron pipe, leading from the reservoir on Ewart Hill down to and through the central or business section of the city. From this main 16-inch line, there radiates and interconnects in every direction the distribution system of 6-, 8-, 10- and 12-inch cast iron pipe, which makes water service available to every dwelling or other building within the limits of the city of Hendersonville. There are only two small sections of pipe less than 6 inches in size; one section

of about 400 feet of 4-inch pipe and another section of 1200 feet of 4-inch pipe.

There are 231 fire hydrants, properly spaced, all hydrants in the business section being of the steamer type and in the residence section every other hydrant being of the steamer type, the pressure ranging from 60 up to 110 pounds, with an average over the larger section of the city of about 85 pounds, thus giving ample fire protection to every section. Columbian fire hydrants and Columbian hub-end gate valves, manufactured by the Columbian Iron Works of Chattanooga, Tennessee, are used exclusively. There are more than 40 miles of distribution pipe within the city limits, which, together with hydrants, valves, fittings and appurtenances, represent an investment of $358,357.14.

OUT-OF-TOWN DISTRIBUTION

Under contracts executed since the new water supply was installed, the city is furnishing water to practically all of the communities within a range of 3 miles of the city. We furnish water to Flat Rock, East Flat Rock, Laurel Park, Druid Hills, Balfour and others. All of this out-of-town service is covered by special contract made with the people installing water lines, the essential portion of these contracts being as follows. (The excerpts herewith are taken from the contract with the Town of East Flat Rock.)

1. The applicant furnishes all rights of way in the name of the Water Board and grants to the Board all necessary rights to lay, operate and maintain water lines along the proposed rights of way.

2. The applicant agrees to pay, and furnishes satisfactory guarantee that he will pay, to the Board, as required by the Board, the actual cost of all water lines laid under this agreement.

3. The Board agrees to furnish and install all of the pipe, hydrants and specials, according to the plans, the Board, however, reserving the right to make changes in said plans, without notice, where, in their judgment, a change in the plans may be necessary for the betterment of the service.

4. The Board agrees to make water taps, install meters, and otherwise furnish water service to consumers on the mains of the applicant under its "Rules, Regulations and Rates," for such service, reserving the right to change or modify its rules, regulations and rates in the manner provided therein.

5. Provides that all water lines and specials installed under the

agreement shall be under the absolute control of the Water Board. The Board reserves and the applicant grants to the Board all rights for making water taps, extensions or replacements.

6. Provides that the Board is under no obligation to furnish water service, except as the elevation of its reservoir will allow a gravity flow.

7. Provides that, should a party or parties with property outside of the city limits and outside of the property specifically covered by the agreement make application for water service from the mains of the applicant, and should the Board see fit to grant the service applied for, the applicant shall be privileged to sell to the party applying for such service a tap, charging therefor an amount which will be a fair and equitable charge for the privilege of tapping the water line at a point where the service may be desired. Should the applicant and the party desiring service be unable to agree on the price, the Board reserves the right to name the amount to be charged.

9. Provides that the Board shall have an option to buy at any time all water lines laid under the agreement and, should the Board decide to exercise this option, the price to be paid will be the actual cost of the pipe of a size 4 inches and above (no consideration to be given pipe other than 4 inches or above in size) hydrants, valves and specials installed, less deductions as follows: All money collected for the sale of taps under Paragraph 7 and depreciation at two and one-half per cent per annum. It is specifically understood, however, that the Board is under no obligation to exercise the option to buy, but simply has the privilege to buy the water lines or any part of them at any time they may desire.

11. Provides that when the money derived from the sale of taps, as outlined in Section 7, shall reach a point whereby the applicant will have been fully reimbursed for the cost of the water lines of a size 4 inches and above and installing hydrants, valves and specials, all water pipe laid under this agreement will automatically revert to the Water Board and become the property of the Board, to be held by them in fee simple, and no further sale of taps can be made by the applicant.

13. Reserves to the Board the right at any time to shut off the water in its mains or the mains of the applicant, without notice and without liability, for the purpose of making repairs or extensions, or for any purpose incident to general waterworks operation, or for the conservation of the supply of water in the city of Hendersonville.

By the terms of an agreement of this kind, which is standard with us, the city of Hendersonville installs all pipe, reserving the right to say what size pipe shall be installed, and, after the pipe has been installed, it is under the absolute control of the Water Board and is operated as an integral part of its water system, in exactly the same manner as our water pipes within the city limits. The applicant pays all of the bills covering the cost of installation. He is, however, relieved of any expense of upkeep, this being assumed by the city. The city installs all meters, reads them and collects and keeps all water rents, as a part of its revenue, in the same manner as is done with consumers in the city of Hendersonville. The parties installing the lines are privileged to get as much of their money back as possible by the sale of taps to those who may live along the line of their pipe. In this way, it is the idea of the Board that the initial cost of the work shall eventually be distributed among the various property owners along the pipe line and, when this cost has been properly distributed, it is their plan that the water pipes will then revert to the Water Board as a part of its assets, to be used, of course, in serving water to the property owners and residents along its line. Since this agreement was put into effect, we have laid not less than 28 miles of cast iron pipe, ranging in size from 4 to 10 inches and possibly as much more of 2- and 3-inch galvanized pipe. The total investment in distribution lines laid outside of town, but which are actually under the absolute control of the Hendersonville Water Board, amounts to $256,514.92. During this same period we have added 658 consumers living outside of town, with a revenue estimated at approximately $25,000.00 annually.

SUMMARY

The Board of Water Commissioners of the city of Hendersonville owns or controls 24 square miles of watershed, two intake dams, seventeen miles of 16-inch transmission pipe, and seven miles of 20-inch transmission pipe, a five-million-gallon reservoir on Ewart Hill, forty odd miles within and thirty odd miles of cast iron distribution pipe outside of the city of Hendersonville. There are approximately 2300 services, of which 99 percent are metered. All of this represents an investment on the part of the city of $1,052,206.80, to which, of course, is to be added the cost of the out-of-town distribution lines, which was paid by others, the total cost of the plant, inside and outside, being $1,308,721.72.

Hendersonville's water system is controlled by a Board of Water Commissioners composed of three members, who are appointed by and receive their authority directly from the State Legislature. Each member is appointed for a term of six years, one member being elected at each biennial session of the General Assembly. This gives assurance of two experienced members on the Board at all times and a permanence of policies found most practical and guards against sudden radical changes. The personnel of the Board at present is: C. E. Brooks, Chairman, J. W. Bailey, and Dr. W. R. Kirk.

MANIPULATION OF pH AT SPRINGFIELD, ILLINOIS[1]

By Charles H. Spaulding[2]

In a water purification plant where lime is employed, as at Springfield, the pH value of the water is manipulated up and down in order to obtain certain results. These results have a bearing on the softening of the water and also on coagulation, sterilization, and ultimate stabilization. The practical values derived from these variations of pH differ under different circumstances, but an examination of one more actual case may show some of the limitations of the process and help to point the way to better application in the phenomena involved.

At the Springfield plant the raw water is treated with lime in a small dosing well just ahead of the mixing chamber. It is then stirred for forty minutes by mechanical agitators in two parallel mixing chambers from which it flows to clarifiers and settling basins having combined detention periods of five hours and forty minutes at the rated capacity of the plant. A thirty-minute carbonation period follows the settling, and the water then goes to the filters.

The method of feeding the lime is unique in that there is a marked variation each hour in the concentration of the milk of lime flowing to the dosing well. This is due to the fact that the quick lime is weighed into the slaker in hourly batches while a constant stream of water enters the slaker and displaces the milk of lime.

The magnitude of the variation is disclosed by a chart from the recording thermometer which has been placed in the pipe carrying the lime suspension. The purpose of the thermometer is to give a continuous record of lime dosage for the benefit of the operator as well as the superintendent. I believe it is a valuable aid in maintaining the efficiency of the plant. As indicated by the chart, the lime suspension is, roughly, twice as concentrated immediately following the

[1] Presented before the Water Purification Division, the St. Louis Convention, June 5, 1930.

[2] Chemist and Superintendent, Water Purification, Department of Water, Light and Power, Springfield, Ill.

addition of a charge of lime to the slaker than before the addition. When this pulsating treatment was begun it was found to lower the total hardness of the treated water 10 p.p.m. more than could be done with the same amount of lime fed at a uniform rate.

When treating to normal carbonates only, there is considerable fluctuation in the pH and alkalinity of the mixing chamber effluent which is smoothed out by the time the water has passed the clarifiers. When treating to 40 p.p.m. causticity there is but little fluctuation in the alkalinity and the pH varies only 0.1 from 10.7 to 10.8. This is because the magnesium acts as a buffer removing the extra hydroxyl ions furnished by the peaks of the lime dosage.

The recarbonation of the settled water is accomplished with stack gas from the boilers of the nearby pumping station and power plant. The carbonating equipment includes two scrubbers, one gravel filter, one blower, a distributing grid submerged in the carbonating chambers, a CO_2 recorder, and a gas meter. There is also a 2-inch discharge line leading to the filtered water conduit which can be used to reduce the pH of the filtered water. The cost of the equipment was $7000, of which $4500 was for the pipe contract.

The maintenance on the carbonating equipment was considerable at first, due principally to the omission of the scrubber near the boilers. The compressor, which is a rotary displacement blower, has not maintained its full capacity, but we do not find that this is a result of the character of the gas. During the past year the equipment has been operated with but little attention. The percent of CO_2 in the gas is regulated by dilution valves admitting air as required to the suction of the compressor. The quantity applied is regulated by hourly tests of the carbonated water. The items of operating cost are power, $2.40 per day, and water, $0.77 per day, which together amount to 44 cents per million gallons.

The fuel used under the boilers from which this gas is taken is low grade bituminous screenings, containing 4 to 5 percent sulphur. Sulphur dioxide, however, is much more soluble than carbon dioxide, and the greater part is removed in the first scrubbing. There were predictions that chlorophenol tastes would be a problem if this gas were used. A few preliminary tests, however, showed that we had nothing to fear from phenols and the results have been entirely satisfactory in this respect. The soot and tarry compounds caused some trouble in handling the gas, and the single scrubber of the original installation was supplemented by a second scrubber located

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close to the boilers. This materially helped matters, but the gas is still not as clean as could be desired, and various parts of the piping system require flushing-out every six months. Boiler operating conditions at present are far from ideal from the standpoint of clean smoke, but improvements are under way at the boiler plant which will permit better combustion and will probably remedy this situation, though it is not serious.

A comparison of the effects of lower and higher pH values in the treated water can be made by an examination of the plant records for the years 1928 and 1929. In 1928 the settled water had a total alkalinity of 59, of which 1 p.p.m. was caustic and the balance normal carbonates. This water was filtered and the filtered water

TABLE 1

Comparison of 1928 and 1929 results

(Results in p.p.m.)

	1928	1929
Total hardness, raw water	248	230
Total hardness, filtered water	95	81
Total alkalinity, raw water	206	185
Total alkalinity, filtered water	47	35
Magnesium (as $CaCO_3$), raw water	109	100
Magnesium (as $CaCO_3$), filtered water	70	50
Turbidity, raw water	99	103
Lime used, pounds per million gallons	1,386	1,461
Alum used, pounds per million gallons	80	32

partially recarbonated in the filtered water conduit. The final effluent had a total alkalinity of 47, of which 28 p.p.m. were normal carbonates and the balance bicarbonate. In 1929 the settled water had a total alkalinity of 69, of which 35 p.p.m. were caustic and the balance normal carbonates. This water was carbonated before filtering to remove excess lime, and the final effluent averaged 35 p.p.m. total alkalinity, of which 28 p.p.m. were normal carbonates and the balance bicarbonate. Table 1 shows some results of these two treatments.

A comparison of the chemical costs of these two years is shown in table 2.

The record shows that the filtered water was 14 p.p.m. softer during 1929 than the previous year. The apparent lime cost per ton of

hardness removed was $1.38 more in 1929 than the previous year, but, due to the coagulating value of the extra magnesium hydroxide precipitate during 1929, a considerable cut was made in the amount of alum used, and this saving should be deducted from the softening cost. When this is done there is practically no difference in the per ton cost of hardness removed. During both years considerable hardness has been deposited on the filter sand. It has been found that when the sand grains accumulate a coating of scale equal to their own weight, filter efficiency begins to suffer appreciably, and it does not seem advisable to continue the process without replacing the sand. This means that one ton of sand is used in removing a ton of hardness from the water applied to the filters. The cost of filter sand delivered at the plant is $5.00 per ton. Allowing $1.00 per ton for

TABLE 2

Comparison of costs in 1928 and 1929

	1928	1929
Tons hardness removed by lime alone	1,525	1,451
Tons hardness removed on filters	130	199
Total tons hardness removed	1,655	1,650
Tons lime used	1,794	1,922
Tons alum used	104	42
Cost of lime per ton hardness removed	11.00	12.38
Cost of lime corrected for alum saved		11.19
Cost of sand per ton hardness removed	6.00	6.00
Cost of lime and sand per ton hardness removed	10.58	10.56

handling in and out of the filters, brings the total cost of hardness removed in this way to $6.00 per ton, and lowers the average cost of all hardness removed to $10.56 per ton.

In spite of these figures it does not seem advisable to continue this sort of treatment. When settled water of pH 10.8 is recarbonated to 9.3, it is extremely unstable. It not only incrusts the sand, but also the conduit and valves leading to the filters, so that in a few years these might become serious problems. Another problem which may be included among sequelae is magnesium silicate scale in hot water heaters.

Water of 30 to 35 p.p.m. alkalinity and pH 9.3 has shown no tendency to deposit calcium carbonate scale either in cold or hot

water lines, but we have found in hot water systems a scale of which the following is a typical analysis.

	Percent
Loss on drying	6.2
Loss on ignition	17.0
Silica, SiO_2	35.1
Oxides, R_2O_3	3.64
Magnesium oxide	37.5
Undetermined	0.56

Water entering and leaving the heater from which this scale was collected showed the following changes through the heater.

	Entering	*Leaving*
Alkalinity total	32	28
Alkalinity to phenolphthalein	9	8
pH	9.3	9.1
Silica, SiO_2	13.2	7.8
Calcium oxide, CaO	22.6	22.4
Magnesium oxide, MgO	20.7	19.0

These analyses show that magnesium and silica are the important constituents in this case, and that calcium carbonate is out of the picture, except, perhaps, as it affects the pH of the water.

The scale formed is soft, but it adheres sufficiently tightly to effectively close hot water lines if not removed. Until we know more about this sort of scale, it seems advisable to use alum as a coagulant continuously and to keep the pH of the final effluent near 8.4.

Much has been said about sterilizing value of lime, but unless its limitations are recognized, one is liable to a rude awakening. Lime sterilization is a slow process not at all comparable with chlorination. For example, distilled water containing 30,000 B. coli per cubic centimeter treated at 9.0°C. with lime to a causticity of 35 p.p.m., and a pH of 10.7, shows no reduction in two hours and only 53 percent reduction in four hours, although in ten and one-half hours it is sterile. Similar results have been obtained repeatedly in our laboratory. The fact is that the contact period in six-hour basins is insufficient for the sterilizing effects of lime to be at all reliable. It will be realized, of course, that in a six-hour basin much water flows through in three hours or less. We have previously shown that high pH retards the sterilizing action of chlorine, especially if ammonia is present.[3]

[3] Spaulding, C. H.: "Preammoniation at Springfield, Illinois." J. Amer. Water Works Asso., 21: 8, August, 1929.

Recently C. T. Hough has reported the necessity of lowering pH in order to obtain safe water through a softening plant at Lawrence, Kansas.[4]

The bacterial efficiency of the Springfield plant is therefore based almost entirely on coagulation and chlorination. The lime used plays an important part, but not as a sterilizer. The bacterial results for the past year show the B. coli indices at various stages of the process in table 3.

TABLE 3

	B. COLI INDEX PER 100 CC.
Raw	53,930
Clarified	12
Applied	3.3
Filtered	0.55
High service pump suction	0.13
High service pump discharge	0.26
City tap	0.07

DISCUSSION

JOHN D. FLEMING:[5] The increased softening accomplished by the pulsating lime feed used at Mr. Spaulding's plant is probably an unusual exhibition of the phenomenon of overdosing not intentionally being practiced. I can well believe that this 100 per cent variation in lime feed is beneficial as long as waters of low turbidity are treated, but overdosing done in any manner, is inadvisable in the softening of very turbid waters. The waste of lime by absorption on the mud becomes excessive as the concentration of the lime present in the water increases.

The Howard Bend Station at St. Louis uses waste flue gas for carbonating in about the same manner as the Springfield plant, but no difficulties have been encountered comparable to those experienced by Mr. Spaulding, because of the very excellent quality of flue gas and the type of compressor used. A rotary water sealed compressor requiring no close clearance is used instead of the gear

[4] Hough, C. T.: "Problems of Slow Chemical Reactions in Cold Weather." Water Works Engineering, 83: 8, April, 1930.

[5] Chief Chemical Engineer, Water Division, St. Louis, Mo.

type pump which is so easily fouled by the accumulation of hydrocarbon impurities in the gas. No chlorophenol tastes have been developed as a result of using this waste gas.

The black iron pipe distributor originally installed became unserviceable after four months use due to plugging up of the holes more than 5 feet removed from the header, and the corrosion of the others. One brass pipe which had been installed for test purposes remained in almost perfect condition, there being neither corrosion nor plugging of the holes. The distributor is to be rebuilt soon, using brass laterals and cast iron headers.

I believe the dilemma confronting Mr. Spaulding, involving the excess lime treatment, carbonation, and valve, sand and pipe incrustation, exists at nearly every softening plant employing carbonation. The fundamental error consists in the application of the carbon dioxide just before filtration. Insufficient time is allowed between carbonation and filtration for the establishing of chemical equilibria, and the various evils and difficulties recited are the result. Furthermore, the freshly precipitated calcium carbonate suspended in the water increases the filtration load.

The way to avoid this chemical snarl entirely and at the same time reap all the benefits of the treatment is to provide sufficient settling basin capacity to hold the caustic condition of the water for ten or twelve hours before carbonating, and secondary settling basins of four to six hours detention to allow the stabilization and clarification of the carbonated water before filtration. A small charge of alum should be added after carbonation to facilitate the settling of the precipitated calcium carbonate. Sterilization, maximum softening and economical coagulation are thereby achieved, the final sterilization of the filter effluent is effected with a minimum of chlorine, and tastes and incrustation of sand, valves etc. are avoided.

CHARLES P. HOOVER:[6] Mr. Spaulding's observation that over-dosing and under-dosing with lime lowered the total hardness of the treated water at Springfield, 10 p.p.m. more than could be done with the same amount of lime fed at a uniform rate, confirms in this respect our experience at Columbus, Ohio with the so-called split treatment process. His method of applying lime, in reality, amounts to the same thing as split treatment, that is treating a portion of the

[6] Superintendent, Water and Sewage Disposal, Columbus, O.

hard water with all of the lime and then neutralizing the excess lime with raw water.

Split treatment reduces the hardness of a given quantity of water with a given quantity of chemicals more than the same quantity of chemicals will when added in the usual way because magnesium compounds are not completely precipitated from the water unless the pH of the water is high. In other words, in order to get satisfactory precipitation of magnesium, excess lime must be added in sufficient quantity to render the water caustic. It is not good practice to deliver highly caustic water to the consumers. Therefore, if excess lime is used it should be neutralized after the magnesium has been precipitated. In the days before carbonation or neutralization of excess lime or caustic alkalinity by CO_2 gas, it was recognized that only a portion of the magnesium could be removed by the excess lime treatment because, if part of the water was overtreated with lime, the other portion could not be treated at all or only slightly for the untreated portion would have to be used to neutralize the overtreated portion. The magnesium would therefore be satisfactorily removed only from the overtreated portion.

There are several questions that I should like to ask regarding Mr. Spaulding's paper:

1. He says that a continuous record of the lime dosage is obtained by thermometer readings. In the process of slaking lime with water, there is of course an increase in temperature, but it will be interesting to know if this increase in temperature has been translated so as to give an index of the lime dosage.

2. Regarding the presence of magnesium silicate scale in hot water heaters. It would be interesting to know why he believes the addition of alum to the water will prevent the formation of magnesium silicate scale.

The last few paragraphs of Mr. Spaulding's paper might perhaps create the impression that lime has little sterilizing value. Its use over a period of many years at a number of water softening and purification plants, I believe, proves its worth.

Mr. Spaulding's results, table 3, show a remarkable B. coli index reduction, from 53,930 in the raw water to 12 in the clarified water. It is reasonable to assume that the lime treatment was a real factor in this tremendous reduction of B. coli. If not by direct slaughter, most certainly the large bulky precipitate produced as a result of the water softening reactions, which perhaps is from 15 to 20 times

as great as could be obtained by ordinary coagulation processes, plays an important rôle in the removal of bacteria.

The performance of six water softening plants in Ohio is shown in table 4. B. coli indices on raw and lime softened unchlorinated water are shown by months for Columbus, Fremont, Greenville, Newark, Piqua and Youngstown.

The results show that all of these plants produce water that meets the U. S. Treasury Department standards. That is, the lime softened without the use of chlorine meets the Treasury standards.

TABLE 4

B. coli per 100 cc. in raw and unchlorinated lime softened water

1929	COLUMBUS		FREMONT		GREENVILLE		NEWARK		PIQUA		YOUNGSTOWN	
	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered
January	655	0.3	626	0	870	0.3	2,523	0.7	2,609	0	3,293	0
February	171	0			1,480	0.9	1,439	0.2	952	0	728	0
March	403	3.5	4,774	3.0	1,760	8.3	784	0.2	1,087	0	5,519	0
April	685	0	8,467	0.1	910	0.3	3,088	0.4	2,170	3.0	8,800	0
May	739	0	2,258	0	2,270	0.4	1,311	0.2	1,477	0	7,067	0
June	120	0	77	0	4,050	0.1	1,234	1.0	843	0	1,646	0.6
July	252	0.7	6,780	0.1	*	*	928	0.4	1,161	0	2,309	0
August	123	0	1,132	0	*	*	362	0	965	0	3,806	0
September	157	0	250	0	*	*	550	0	97	0	808	0
October	335	0	530	0	*	*	141	0.2	7	0	407	0
November	663	0.1	7,270	5.0	300	0	2,696	1.0	132	0	21,286	0
December	526	0	3,845	1.6	656	0.5	1,450	0.4	542	0	16,951	0
Average	402	0.4	3,274	1.0	1,537	1.4	1,376	0.4	1,004	0.3	6,052	0.05

*Pump well water.

The loads vary from 21286 B. coli per 100 cc. to as low as 7. Some of the plants do not use any chlorine at all, some use it all the time and others only occasionally. It is applied after filtration and is used as an additional safeguard or factor of safety. These plants have retention periods on design basis varying from three and one-half to nine and one-third hours and based on average present consumption of 9.1 to twenty-three hours. Although the retention period on average present consumption is from 9.1 to twenty-three hours, some of these plants actually operate at the design basis rate

during a portion of the day and then shut down so that the period of contact more nearly approaches the time for which the plants were ultimately designed to operate.

Dr. A. C. Houston, Chemist of the Metropolitan Water Board, London, England in the Eighth Research Report of the Metropolitan

TABLE 5

Capacity for which plant was designed and present water consumption

CITY	SOURCE OF SUPPLY	M.G.D.	
		Design basis	Present water consumption
Columbus	Scioto River	54.0	30.0
Fremont	Sandusky River	3.0	1.0
Greenville	Greenville Creek	1.0	0.6
Newark	Licking River	6.0	2.4
Piqua	Hydraulic and Miami River	5.0	1.6
Youngstown	Mahoning River	25.0	13.2

TABLE 6

Retention or reaction time of lime with water

CITY	RETENTION PERIOD, HOURS							
	Design basis				Present water consumption basis			
	Mixing	Clarifier	Sediment	Total	Mixing	Clarifier	Sediment	Total
Columbus	½		6	6½	1		10.0	11
Fremont	½	1	2	3½	1–½	3.0	6.0	10½
Greenville	1	½	4	5½	1.6	0.8	6.7	9.1
Newark	1	⅓	8	9–⅓	2–½	¾	20.0	23.0
Piqua	½	1–⅓	2	4	1–½	4.0	6.0	11½
Youngstown	0	0	8	8			15.0	15

Water Board found that quicklime added to raw Thames water in the proportion of 1 part of quicklime to 5,000 parts of water, (about 11.7 grains per gallon, kills B. coli in five to twenty-four hours.

Results at Columbus indicate the following conclusions:

1. When enough lime is added to water to absorb the free and half-bound carbonic acid, and to precipitate the magnesium, the

bacteria of the colon and typhoid group are killed in forty-eight hours after being so treated, provided the water does not contain large quantities of organic matter.

2. The germicidal action is effective in from five to twenty-four hours when an excess of one-half to one grain per gallon is added beyond that needed to reduce the temporary hardness to the lowest possible figure.

3. Lime softened water inoculated with typhoid organisms soon becomes free from them.

4. When organic matter is low and the B. coli index is low, a shorter lime reaction time is necessary than when organic matter is high and the B. coli index is high.

CHARLES H. SPAULDING:[2] The question has been asked how the temperature chart shows the quantity of lime used. The amount of heat liberated by slaking a given amount of lime is a perfectly definite quantity, and if this quantity is determined, the amount of lime can be computed. This determination involves metering the water used for slaking and measuring the temperature at the inlet and outlet of the slaker as well as protection against radiation losses or allowance for them. We do not go this far in our operation, but since the quantity and temperature of the slaking water are practically constant throughout the day, any increase or decrease in lime used shows as a corresponding rise or fall of the temperature curve, thus giving a continuous check on the dosage.

As to the use of alum to prevent magnesium silicate scale, we know that aluminum sulphate assists in magnesium removal, and we observed higher silica content of the filtered water during the time that alum was omitted. At present this is the only evidence we have that alum will help to prevent this scale.

Mr. Hoover has expressed the fear that doubts may be raised by some paragraphs in this paper as to the efficiency of lime in bacterial purification. It has been my purpose in this part merely to point out that the value of lime in short period basins depends on precipitation, probably of magnesium hydroxide. We have frequently observed a decided drop in the bacterial efficiency of our basins when the magnesium content of raw water was lowered by heavy showers or when low temperatures retarded the precipitation of magnesium. This might easily escape observation elsewhere, since it would only appear where the actual detention period is considerably less than ten

hours and where heavy bacterial loads are combined with relatively light magnesium precipitation. Our laboratory experiments were made because it was found that high pH would not produce a standard effluent under such conditions. I reported B. coli removal in distilled water because it permits easier standardization, but similar results have been obtained with river water. I should expect the high concentrations and the purity of the distilled water to favor the death of the organisms. The initial count of 30,000 per cubic centimeter is not so far above the index of 10,000 per cubic centimeter which we have had on consecutive days.

In view of the Springfield results and many others, I thoroughly endorse the proposition that the usual lime softening plant shows a high bacterial efficiency, but in this case it has been necessary to discover the limitations of high pH as a sterilizer in order to obtain the best results from the lime.

AN IMPROVED FERROCYANIDE-CITRATE AGAR FOR DIRECT ENUMERATION OF COLON-AEROGENES ORGANISMS[1]

By Fred O. Tonney[2] and Ralph E. Noble[2]

In employing ferrocyanide-citrate agar (1) to obtain direct counts of colon-aerogenes organisms in feces, soils, vegetation, sewage and water supplies (2), we have been impressed by certain practical advantages of the direct plating method which suggests that a simplified technic, adapted to routine requirements, may prove to be useful in water analysis.

Briefly these advantages over the usual fermentation methods are as follows:

1. The direct count is less subject to error and is inherently more accurate than an estimate of numbers based on inoculation of fractional portions of the sample in a series of tubes of liquid medium.

2. The plating process is simple, consisting only of planting the plates and counting the colonies. When ferrocyanide-citrate agar is employed, further confirmatory steps appear to be unnecessary in ordinary routine.

3. The completed findings are obtained in a shorter time; viz., in thirty-six to forty-two hours. Presumptive indications are available in about twenty-eight hours.

4. Less labor is required.

5. The direct counts on ferrocyanide-citrate agar are not obscured by overgrowths and are not interfered with by common lactose-fermenting organisms.

6. For obtaining pure cultures of Bact. coli or Bact. aerogenes, the poured plate, as a source from which to fish colonies, is much superior to Endo's medium or eosin methylene blue agar, inoculated by the surface streak method.

7. By means of the distinctive appearance of the colon-aerogenes

[1] Revised form of manuscript presented before the Water Purification Division, the St. Louis Convention, June 5, 1931.

[2] Bureau of Laboratories and Research, Department of Health, Chicago, Ill.

colonies in ferrocyanide-citrate agar, separate counts of the Bact. coli and Bact. aerogenes types are easily obtainable, as well as the total group count. The differentiation of the two types of organisms based on the colony appearance, gives a high degree of confirmation by other differential tests (3, 4).

8. The additional data thus obtained give promise of usefulness in judging the sanitary quality of water supplies (3, 4).

THE MODIFIED TECHNIC

The technic originally employed has been much simplified and the productivity of the medium for growth of colon-aerogenes organisms considerably improved.

Stock agar

Difco "special agar for cyanide-citrate medium." This specially prepared agar may be obtained from the Digestive Ferments Company, Detroit, Michigan.[3] It does not require the four-day soaking and is fully as satisfactory as shredded agar washed by our recommended procedure. For use, it is simply made up, without preliminary treatment, to a concentration of 1.75 percent in distilled water. When dissolved it is filtered and run into sterile, cotton-plugged bottles of suitable capacity, usually of 4-ounce size. These are capped with paper, steamed in an Arnold sterilizer for fifteen minutes and labeled.[4] Adjustment of pH is unnecessary.

Shredded agar, washed. Three hundred grams of agar are placed in a cheesecloth bag[5] and soaked in 20 liters of distilled water which is changed daily for four days. The wash water is then replaced by distilled water to make 10 or 15 liters, as the case may be. If fermentation occurs during the process as evidenced by bubbling, the agar is made up to 10 liters (or 3 percent), and if fermentation has not occurred it is made up to 15 liters (or 2 percent), for proper consistency. It is then filtered and run into sterile, cotton-plugged bottles of suitable capacity, usually 4-ounce. These are capped with paper, autoclaved or steamed in an Arnold sterilizer for fifteen minutes and labeled.[4] Adjustment of pH is unnecessary.

With poorer grades of agar it may be necessary to test out the washing time and the percentage of agar required to give the right consistency. Reducing

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[3] In ordering, specify "special washed agar for ferrocyanide-citrate medium."

[4] The portion of stock agar intended for "covering" the poured plates, may be placed in larger containers if more convenient.

[5] For soaking shredded agar, a satisfactory bag is made from four thicknesses of cheesecloth, folded to approximately 16 by 15 inches sewed across bottom and sides and also about 3 inches from each side of the top, to give an opening of about 9 inches. Such a bag permits the changing of water without loss of agar.

the washing time to one or two days or increasing the final percentage of agar will give a firmer consistency. The finished stock agar should be of about the consistency of 1.5 percent standard agar, made from ordinary unwashed shredded agar of good quality.

Unwashed agar. Ordinary Difco agar ("Bacto Agar," Digestive Ferments Company) and ordinary unwashed shredded agar may also be used for cyanide-citrate agar in a concentration of 1.5 to 1.75 percent, but the unwashed preparations yield fewer colon-aerogenes colonies and are subject to greater fluctuation in quality.

Solutions "A" and "B"

All essential ingredients except ferric citrate are contained in solution "A." Ferric citrate constitutes solution "B."

Solution "A." Approximately 1 liter is prepared according to the following formula: Proportionate amounts may be made up in any quantity.

[6] Anhydrous sodium sulphite (Na_2SO_3) C.P.	4.6 grams
[6] Acid potassium phosphate (KH_2PO_4) C.P.	16.8 grams
[6] Sodium ammonium phosphate ($NaNH_4H \cdot 4H_2O$) C.P.	50.4 grams
Sterile distilled water	170.0 cc.
20 per cent lactose, sterile[7]	420.0 cc.
[6,8] Basic fuchsin, 10 grams in 100 cc. alcohol (95 percent)[9]	8.4 cc.
[6] 0.625 per cent potassium ferrocyanide, sterile (7) $K_4Fe(CN)_6 \cdot 3H_2O$ C.P.	400.0 cc.

Solution "B."[6,10] One and eleven hundredths per cent ferric citrate.[7] This solution keeps at room temperature as well as in the ice-box, except for evaporation from cotton-plugged containers.

It is preferable, but not essential, to add the ingredients of solution "A" in the order given. The phosphate salts and sulphite need not be dissolved completely before the dye and potassium ferrocyanide are added, but if the solution is to be used immediately, care should be taken to have all ingredients in solution before it is added to the agar. The solution keeps on ice for at least four days.

Basic fuchsin. Various brands of basic fuchsin differ considerably in their chemical properties. Arrangements have therefore been made with Coleman and Bell, Norwood, Ohio, to supply to the trade, on request, a basic fuchsin tested by us for use in cyanide-citrate agar and found to be satisfactory. This special stock will be reserved under serial number for such use.

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[6] Mortarize if not finely divided.

[7] Heat in an Arnold sterilizer fifteen minutes only.

[8] Coleman and Bell (special lot, tested for use in cyanide-citrate agar).

[9] Allow to stand twenty hours in a glass or rubber stoppered container shaking frequently and use the filtrate.

[10] U.S.P. VIII: "Scales—soluble," Merck and Company, or "Granular—soluble," Chas. Pfizer and Company, Inc.

PLATING TECHNIC

Plates. The medium is probably best used in standard sized petri dishes (about 90 by 10 mm.). When 10^{11} cc. water portions are to be tested, the water is first added to the plate. When 1 cc. or less is to be tested, 10^{11} cc. of sterile distilled water are first added to the plate, after which the 1 cc. or less amount of inoculant is introduced.

The medium. To 100 cc. of melted stock agar cooled to 75°C. (estimated) are added 9 cc. of solution "A," which is first agitated, and the contents mixed by shaking. Three and six tenths cubic centimeters of solution "B" are then added while the bottle is being shaken. Other volumes of stock agar may be used, in which case the quantities of solutions "A" and "B" are changed proportionately.

As soon as the bluish pink medium has cooled to about 46°C., or nearer 50°C. if the plate contents are cold, 20 cc. are added to the plate with a "quick delivery" 20 cc. pipette.[12] The medium should be drawn somewhat above the 20 cc. mark to compensate for that which clings to the tube. A trial or two will quickly determine the amount. It is best not to wait for complete delivery of the graduated amount, as this shortens the time available for satisfactory mixing of plate contents.

The cover. After the plates have hardened, approximately 4 cc. of stock agar are used to "cover" the surface. As soon as the "cover" hardens, the plates are inverted, and placed not more than three high, in a 37°C. incubator. In about thirty-six to forty-two hours they will be ready for counting by means of an illuminated chamber. The plates should be inspected in about twenty-four to twenty-eight hours and read if sufficiently grown.

Suggestion. In working with the medium for the first time, it is suggested that plates be inoculated with about 50 to 100 organisms of pure cultures of known Bact. coli and Bact. aerogenes types, from distilled water suspensions titred by means of plain agar plates and stored in an ice-box. Such suspensions will keep for several weeks. This will give the worker an idea of what to expect in a plate from a test sample.

[11] To save time, 10 cc. quantities are introduced with a "quick delivery" (large tipped) pipette.

[12] A home-made and calibrated pipette is satisfactory.

Preparation of pure culture suspensions of Bact. coli and Bact. aerogenes for control purposes in differentiating colony characteristics

Stock suspension. 1. To an agar slant culture, add sterile distilled water until the growth is just covered.

2. Roll the tube vigorously between the hands to wash off the growth.

3. Transfer to a flask containing about 300 cc. of sterile distilled water and store in an ice-box. The suspensions should be kept continuously in the ice-box and removed only long enough to make working suspensions as described in paragraph 6. Kept in this manner the stock suspension will remain in usable condition for about one month.

4. Plate out about four decimal dilutions (e.g., 1:1,000, 1:10,000, 1:100,000, 1:1,000,000), using five plates each of ferrocyanide-citrate agar or plain nutrient agar, and incubate.

5. The lowest dilution giving the largest countable number is taken as the most reliable titre of the stock suspension. After the first or second trial, one can judge the approximate amount of culture suspension to be added to a given volume of water by the turbidity in paragraph 1.

Working suspension. 6. Working suspensions are then made from stock suspensions by transferring the calculated amount, by intermediate dilution if necessary, to a measured volume of sterile water.

Example. Given: A stock suspension containing 53 Bact. coli (5-plate average) in the 1:1,000,000 dilution and a stock suspension containing 41 Bact. aerogenes (5-plate average) in the 1:1,000 dilution.

To prepare. A 100 cc. working suspension containing approximately 85 Bact. coli and 85 Bact. aerogenes per 1 cc.

Method. Add to a 99 cc. sterile water blank, 1.6 cc. of 1:10,000 dilution of the coli stock suspension and 0.2 cc. of the undiluted aerogenes stock suspension. The resulting mixture will contain, theoretically, approximately 85 Bact. coli and 82 Bact. aerogenes organisms per 1 cc.

An illuminated chamber for counting cyanide-citrate agar plates

The best lighting conditions for counting colonies in the cyanide-citrate agar plates are produced by indirect, well-diffused light, with a white background. Direct light may be used but gives less satisfactory differentiation of the colonies.

The cabinet is constructed of $\frac{1}{2}$-inch and $\frac{3}{4}$-inch lumber of the following dimensions: (see fig. 1).

Base: 20 by $9\frac{1}{2}$ by $\frac{3}{4}$ inches (1 inch margin extends around base of chamber on all sides).
Front wall: 18 by $3\frac{1}{4}$ by $\frac{1}{2}$ inches.
Rear wall: 18 by $5\frac{7}{8}$ by $\frac{1}{2}$ inches.

FIG. 1

Ends:
Bottom: $6\frac{1}{2}$ inches
Front: $3\frac{1}{4}$ inches } thickness $\frac{1}{2}$ inch.
Rear: $5\frac{3}{4}$ inches
Top (cover) 18 by $7\frac{3}{4}$ by $\frac{1}{2}$ inches (this is hinged at the upper rear edge).

A round hole slightly larger than a petri dish is cut in the center of the top of the box. Directly under the disk opening in the cover is fastened a clear glass counting plate which supports the petri dish.

On the back wall at each end are placed two electric light sockets

centered about 1½-inch from the end. For ventilation, two triangular notches are cut in line with each socket, one in the top of the back wall and one in the bottom of the front wall. Two 4- by 6-inch pieces of ¼-inch asbestos are tacked to the under side of the cover above each lamp socket. Two ordinary 60-watt lamps are installed in the sockets.

The interior of the box is painted a flat white.

With this illuminator the colon-aerogenes colonies stand out on a rose pink background in contrast to extraneous forms.

If it is desired to count ordinary plain agar plates in this illuminator, an additional plate of blue glass 8 by 6¾-inches is leaned from the front wall at the floor to the back wall about 1 inch from the top.

SUMMARY

With the changes in preparation and technic here described, cyanide-citrate agar now possesses advantages of simplicity and improved productivity over the medium as originally reported. The average number of colon-aerogenes colonies produced, equals or slightly exceeds the corresponding plain nutrient agar counts made from the same titred suspensions.

Immediately before use, two solutions containing the essential ingredients are added to the melted agar, and the medium is ready for plating.

The basic fuchsin, which heretofore has been a source of difficulty because of the variable quality of market products, is now standardized by arrangement with the manufacturer, and is available to the trade under special serial number.

An illuminated chamber affording suitable lighting conditions for differentiating and counting colon-aerogenes colonies is described.

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POOLS AND WATERWORKS[1]

By Arthur M. Crane[2]

Here beginneth the 2nd verse of the 5th chapter of the Gospel according to St. John:

Now there is at Jerusalem by the sheep market a pool, which is called in the Hebrew tongue Bethesda, having five porches.

In these lay a great multitude of impotent folk, of blind, halt, withered, waiting for the moving of the water.

For an Angel went down at a certain season into the pool, and troubled the water; whosoever then first after the troubling of the water stepped in was made whole of whatever disease he had.

Here endeth the lesson.

This quotation is cited to show that in ancient times there was a close connection between waterworks and pools.

Bethesda and Siloma were waterworks reservoirs connected to the 25-mile conduit which brought the water to the Holy City from the miscalled "Pools of Solomon."

Today we know that the intermittent disturbance of the water in the pool of Siloma was because it was hooked up also to a gurgitating spring—characteristic of a limestone district. When the pool became agitated, the poor souls unwittingly practicing the "faith cure" envisioned an Angel from Heaven.

In Roman days, the position of superintendent of waterworks was considered a very high honor. And when Sextus Julius Frontinus, who had been Governor of Britain, was appointed Curator Aquarum by Emperor Nero in the year 97 A.D., he found himself not only in charge of the aqueducts, but also of the public pools. Here again was a close connection between waterworks and pools.

At that time several of the eight aqueducts supplying Rome's one and a half million souls with possibly two hundred gallons per capita per diem, were used especially for their pools.

The first of the aqueducts, the Aqua Appia, built by Censor Appius Claudius in 312 B.C., 11 miles in length, supplied that which is

[1] Presented before the Illinois Section meeting, April 24, 1930.

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supposed to have been the earliest of the Roman baths—the "Piscina Publica:" near the Circus Maximus. This was a cold water swimming pool.

By the third century A.D., baths in Rome had become as common as corner saloons before the Volstead era. At that time the census disclosed 952 "thermae" or small establishments, in addition to the 12 large ones, including the gigantic one ascribed to the Emperor Diocletian, estimated to have been 1333 feet long and 1300 feet wide.

Please understand that this is not a plea or suggestion that the municipal pools and baths of today should be placed under the waterworks department. Modern administrative methods rightly place them under the care of the park or recreation department or, in some cities, under a bath commission or department.

But every now and then we do hear of an abandoned waterworks reservoir being converted into a swimming pool. And within about a half hour's ride from this meeting we can see a very recent illustration of a modern close connection between baths and waterworks. This is at the new filtration plant at Kenilworth, Illinois, designed by Pearse, Greeley and Hanson, consulting engineers of Chicago. Here nearly one half of the building has been constructed as a bath-house, fully equipped with showers and lockers and other facilities.

Although modern municipal pools are not under the jurisdiction of the water department, this department is frequently called upon for advice by the authorities in charge of the pools or for assistance, as, for example, in having the waterworks filtration plant laboratory make the frequent water tests required by up-to-date practice and regulations.

So it is that the waterworks man and the waterworks associations should take an interest in muncipal swimming pools. The necessity for this is not only because of the fast growing number of large outdoor pools, but because of the increasing number of States enacting regulations containing sections of direct interest to the waterworks superintendent, even though the enforcement of the regulation might be up to the health authority, as, for example, in the matter of "cross connections."

Doubtless the old Romans had "rules and regulations" for pools and other baths, for they were strong on rules. And it seems that they had some of the latest modern ideas, for the plan of the Baths of Pompeii show the "latrina" immediately at the left of the entrance.

One of the ideals for which we have been striving for the last twenty or thirty years has been: "Make them go to the toilet before they go in the pool."

Anyway in the statutes of A.D. 1176 of the town of Teruel in Aragon, there were careful provisions as to the use and maintenance of the public bath.

At the time of the formation of the American Association for Promoting Hygiene and Public Baths in 1912, no state had issued regulations. Immediately after our organization, the writer was delegated to make an exhaustive survey. According to the late Doctor Simon Baruch, the revered founder of the Association, in 1900 there were only 67 public pools in this country. My survey of 1912 disclosed a total of 540 of all types, public and private, and I may have missed a few.

My report at our 1913 Convention, based in part on my intimate personal contact with 65 pools, concluded with certain definite recommendations which were the basis of the Association's Swimming pool Standards adopted in 1915. These were the forerunner of the state regulations of today; and, in fact, were for the time being used almost "in toto" by a few states.

California is popularly given the honor of having been the first state to adopt regulations, in 1917, and it may have been the first to enact a statute; but the fact stands that Louisiana adopted regulations, February 26, 1913.

However the California regulations set the pace and each year has seen additional states fall into line. This has been aided largely by the Joint Committee on Bathing Places of the Conference of State Sanitary Engineers and the American Public Health Association.

Originally there was great divergence in the regulations; but since the promulgation of the Committee's 1927 report, they are becoming more uniform. The January, 1930, number of *The Journal of the American Association for Hygiene and Baths* contains the regulations of 29 States and shows that the same number of States require that plans must be submitted to, or a permit secured from, or the pool registered with, or reports made to the State Board or Department of Health. Of these, 4 States—Iowa, Missouri, Rhode Island and South Dakota admittedly use the Report of the Joint Committee as a guide in administering their regulations.

And 7 other States which have no regulations—Alabama, Arizona, Delaware, Georgia, Illinois, North Carolina and Virginia,—counsel observance of the said Report.

Eight other States contemplate regulations, namely—Alaska, Hawaii, Montana, New Jersey, North Dakota, Ohio, Pennsylvania and Wisconsin.

Our own State of Illinois, while lacking regulations, supervises by analysis, provided monthly records are submitted on forms furnished by the Illinois State Department of Public Health. And this State is very fortunate in having this control in the hands of its Chief Sanitary Engineer who is a member of both sections of the Joint Committee of the Conference of State Sanitary Engineers and the American Public Health Association.

The large artificial outdoor pool is a comparatively new thing, but they are coming "on the run."

When I made my investigation in 1912 there were very few of them. Of the 250 which reported dimensions, only one was comparable with today's outdoor pools. It was 145 feet long and 65 feet wide, containing something like 375,000 gallons. That is the same capacity as the largest of the present 59 U. S. Army pools, at Camp Harry J. Jones in Arizona.

Today a half million gallon pool is no novelty and there are a number ranging from 1 to 2 million gallons. In fact, Buffalo has a mere wading pool containing 2 million gallons, the one in Humboldt Park, the area of which is 213,000 square feet.

With the increasing pollution of our natural bathing places in streams and lakes which is driving the people to pools; and the advances in legislation and orders of water companies preventing bathing on watersheds or in reservoirs; a vast number of artificial pools will necessarily be constructed.

According to Health Commissioner H. L. Rockwood, Cleveland will abandon the use of Lake Erie for bathing places, because of its menance to health. That means more pools.

The Hackensack Water Company recently acquired title to all properties surrounding the "old swimming hole" at Walter's Dock in Warrington Park at Bergenfield, N. J. and has forbidden further swimming or bathing there. Other illustrations might be given.

Along both the Atlantic and Pacific Coasts, at such resorts as Atlantic City, Asbury Park, etc., artificial pools right at the ocean's edge have been in use for many years and it is only a question of time until the cities on the Great Lakes and rivers throughout the country recognize the advisability of following the example of the coast resorts.

The early pools were mostly of the "fill and draw" type. Even

if there was a constant flow, it was of trivial volume and primarily for ornamental purposes. When the water got thick enough and the scum began to stick, the pool was put out of commission and refilled. Today re-filtration is the rule. In fact some communities could not spare enough water to operate by the constant flow method and keep within the State regulations. For example: At Estherville, Iowa, without re-filtration the quantity to refill or change once a day its 375,000 gallon pool would equal 75 gallons per day for each of its 5000 inhabitants.

Like many another common practice, refiltration came into general use in this country by accident. The 23rd Street Y. M. C. A., New York, had its pool on the top of the building and water was drawn therefrom to flush the toilets in the dormitories and throughout the building, so as to provide a constant make-up of new water for the pool. Eventually the draft became so great that the pool heating system could not keep up with it. The engineer of the building solved his own problem simply by cross-connecting the suction of the pool pump with the pool drain and circulating through one of the two filters with which the building had been equipped.

The scheme came to the writer's attention through a visit to see about new filter beds. Its possibilities for purification were at once apparent. The Pawtucket, R. I., Y. M. C. A. were installing a filter for their pool and were induced to add a circulating pump. That was in November, 1906. After a trial, the State Board of Health gave us a great send-off by certifying that after 11 weeks' use the water was purer than when introduced into the pool.

The Pawtucket installation, so far as I know, was the beginning of refiltration for purification in this country. Of course at Pawtucket and for many later installations we adhered to the municipal filtration plant rate of 2 gallons per square foot of surface area per minute. But today, when it is recognized that filtration and disinfection go hand in hand, the standard swimming pool rate is 3 gallons per square foot per minute.

The original installation was a pressure filter and the pressure filter has continued to be regarded as the normal thing for pools, even in States where they are not approved for waterworks.

The American Association for Hygiene and Baths, while recommending that the design of a pool be placed in the hands of a competent consulting engineer, stands ready, as it has always done, to start anyone on the right path by giving preliminary advice and putting them in touch with experts, regarding equipment, etc.

TREATMENT OF WATER AT APPLETON, WISCONSIN[1]

By Arthur J. Hall[2]

Pure water is better than purified water, but pure water is becoming more and more difficult to secure in quantity and quality, so that in the near future many cities will have to content themselves by accepting a moderately poluted source of supply and thoroughly purifying its water, rather than going to a large expense in obtaining a faultless supply which might have to be purified at some later day.

It is hopeless and unreasonable to expect an upstream city to so treat its sewage and otherwise protect the water of a stream which it has a right to use, as to deliver its water to the down stream city "undiminished in quantity and undamaged in quality." The common law may order such neighborly action, but the demand is both impractical and unfair. Inasmuch as the lower city should in any event, erect purification works to care for its water supply it would be unjust to require those living higher up to attempt the conversion of their sewage and trade waste into drinking water before turning the effluent into the stream. The burden of the improvement should be divided, and all that could in fairness be asked should not go beyond so protecting the water of the stream as to permit of its being delivered to the water works intake in such condition as to allow of its being used without undue difficulty or expense as a "raw" water for modern purification works.

The State Board of Health, under the direction of L. F. Warrick, State Sanitary Engineer, are doing a great deal of good work on stream pollution in this state and surface waters are becoming less instead of more grossly polluted in the future. In any event cities receiving their water supply from surface sources and in a good many cases from underground sources will have to face the problem of satisfactorily removing bacteria from these waters so polluted.

In case of an underground water supply that may meet all the requirements of the standards for drinking water as outlined by The

[1] Presented before the Wisconsin Section meeting, August 21, 1930.

[2] Chemist and Superintendent, Water Works, Appleton, Wis.

American Public Health Association, with the exception of a moderately high bacteria count, simple chlorination will be sufficient. At this point I wish to make the statement that, if I were in charge of a water works that received its water supply from underground sources, I would chlorinate the water whether the bacteria count warranted it or not because there is no predicting at what instant pollution might creep in and cause serious results.

Chlorination does not alter the character of the water but does insure the consumer of a safe water supply at all times. The cost of chlorination after the equipment has been paid for is very small and would not seriously change the operating cost of even the smallest utility. I firmly believe in the slogan "The only safe water to drink is sterilized water," and that chlorination should be standard procedure in every water works plant. To me chlorination is a necessity in just the same manner that pasteurization is a necessity to a good milk supply. In many cases where chlorination is suggested it brings about complaints from the consumers, but by proper educational methods these objections can be overcome. In some instances it may be wise to install chlorinating equipment and chlorinate the supply without giving it any publicity until after the water supply has been chlorinated for some period.

In dealing with polluted surface waters the problem becomes more difficult as purification works must be designed and built to purify the particular water in question and the removal of bacteria becomes a problem associated with removal of color, turbidity, taste, odor and sometimes iron and manganese and, in several instances, also water softening.

The removal of turbidity is worthy of considerable attention in removing bacteria from polluted water. While bacteria are not removed in direct proportion to the turbidity removed by filtration, their removals are in parallel. The removal of turbidity may be used as an approximate index of bacteria removal and while not very accurate it has the advantage that it can be determined immediately, whereas it is necessary to wait twenty-four hours for bacteria count and forty-eight hours for presumptive B. coli determinations. It is necessary, however, to have a thorough knowledge of how the bacteria count usually runs in the water to predict the bacteria count that may be expected from the clarity of the filtered water. After several years of operation of a filter plant where accurate turbidity measurements are made fairly accurate results may be predicted.

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I have recently patented a comparator table to show the turbidity, color removal, and state of coagulation of the raw, settled, and filtered water and find this equipment a valuable aid in controlling the purification process and the quality of the water. By the use of this comparator the character of the floc is constantly before the operator and, as the nature of the floc is a guide in the purification of polluted water, this is a very desirable feature. I have had one of these comparators in our plant for the last two years and find it a very valuable piece of equipment in operation.

Aeration of water has always held in the public mind a position of prime importance as a means of purification. There is unquestioned benefit arising from the passage of water over falls and rapids, and from it being thrown into the air in fountains, but the benefit is not very great from a standpoint of bacterial removal. At the Appleton plant, where we have had an aerator for the past ten years, during all this period I have noticed no appreciable change in the bacteria count after aeration. We do eliminate, however, taste and odor due to algae and get better results in our chemical reactions by the use of this aerator. Our aerator being built outside of the building cannot be used during the colder months, but during the last year I have installed an inside aerator to be used during the months that the outside one cannot be used. As in the case with the outside aerator the inside one increases the efficiency of chemical treatment and improves the taste of the water.

Prechlorination has been in use at the Appleton plant for the past three years and to me this has been the greatest improvement in operation that we have made. At the Appleton plant we have approximately a sixteen-hour retention period in our settling basins and with this long settling period and prechlorination we are able to keep B. coli absent in 10 cc. samples in the settled water. We find the correct amount of the prechlorine dose is three times the final dose. The settled water as it comes in on the filters has no residual chlorine in it, but we carry a residual of 0.1 p.p.m. on the final dose as the water leaves the plant. In the control of bacteria removal there is no factor that requires as close attention and is more important than the chlorination process. The operators at our plant are all taught how to make the ortho-tolidin test for residual chlorine and this test is made every two hours on the even hours and the chlorine is weighed on the scales every two hours on the odd hours so we have an hourly check on the chlorine dose. We have two Wallace

and Tiernan vacuum feed machines and we use one for prechlorination and the other for final chlorination. We contemplate buying an additional machine to hold in reserve should either of the other machines require repairs.

Proper attention should always be given to the condition of the sedimentation basins in order to effect a good bacteria removal. In the summer months it is necessary to clean our basins every six weeks. The number of hours of settling also has considerable influence on the bacteria removal and after exhaustive tests on settling periods prior to the building of new settling basins I came to the conclusion that a minimum of eight hours was needed to get a bacterial efficiency of around 95 percent. Prior to the building of these additional basins and with only two to four hours settling it was impossible to get a bacterial efficiency of over 50 percent. This, of course, was without prechlorination.

Accurate care and control of the filters is necessary in order to have efficient operation of a purification plant for the removal of bacteria. Our filters are washed with a 24-inch vertical rise per minute for 3 minutes which we have found to be sufficient time for the washing period. The filter beds are frequently sterilized and the concrete walls of the filters are kept scrupulously clean. The experiments carried out at the Detroit experimental plant on higher rates of wash are worthy of favorable comment and it would be a decided advantage if all plants were equipped to use a higher rate of wash during the summer months when the water is warm. During the cold months we do not experience any difficulty with the 24-inch rise.

The filter to waste or commonly called the "rewash" has been abandoned at the Appleton plant because we could see no difference in results when the filter was allowed to filter to waste for ten minutes than when the filter was started immediately. In other words, the water was as good when the filter was first started as it was after five, ten, or fifteen minutes rewash.

DIFFERENTIAL TESTS FOR THE COLON-AEROGENES GROUPS

By Charles F. Poe[1]

Since B. coli was first isolated in 1885 by Escherich (1), this organism and others closely related to it have attracted much attention from a sanitary point of view. Certain members of the colon group have long been known to be inhabitants of the intestines of all warm-blooded animals and hence their presence in water supplies has been taken as an indication of fecal contamination.

The indications of the presence of the members of the aerogenes group of bacteria, a group closely related to the colon group, in water supplies have long been a source of controversy among bacteriologists. This group has many reactions very similar to the colon group, and, therefore, it is somewhat difficult to separate them. Some hold that the presence of members of either of these groups in water supplies is sufficient evidence for the condemnation of the supply for drinking purposes. As late as 1923, the official method for the determination of the potability of a water supply did not take into consideration the separation of these two groups. The 1923 edition of the "Standard Methods of Water Analysis" (2) made the following statement: "It is recommended that the B. coli group be considered as including all non-spore-forming bacilli which ferment lactose with gas formation and grow aerobically on standard solid media." The last edition (3) does not attempt to separate the two groups as may be seen by the following statement: "The formation of gas in lactose broth and the demonstration of Gram-negative non-spore-forming bacilli in the agar culture shall be considered a satisfactory completed test, demonstrating the presence of a member of the coli-aerogenes group."

The above definitions give almost equal weight to both the colon and the aerogenes groups of bacteria. If members of the colon group are predominantly of fecal and those of the aerogenes group predominantly of non-fecal origin, such an inclusion is not consistent. In

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other words, the presence of the aerogenes group in a water supply is not sufficient evidence of pollution for condemnation of the supply.

The exceedingly wide distribution in nature of the members of the colon-aerogenes groups of bacteria has been noted by many investigators. Some have found members of the colon group in places which were supposed to be free from fecal contamination. Klein and Houston (4) found that typical colon organisms were present on grains. Other investigators working with grains, fruits, vegetables, etc. have also noted the presence of these organisms; Laurent (5), Papsotirin (6), Duggeli (7), (8), Metcalf (9), Johnson (10), Prescott (11), and others. Some of these admitted the possibility of fecal contamination, while others claimed that such contamination was exceedingly improbable. Many of the earlier investigators, however, did not attempt to distinguish between the colon and aerogenes groups.

On the other hand, we find a number of workers who claim that such organisms are probably not normally found on such materials, especially grains. These include Winslow and Walker (12), Neuman (13), and Rogers, Clark, and Evans (14). A number of investigators have isolated characteristic colon organisms, methyl red positive and Voges-Proskauer negative, from soils which were not supposed to contain fecal contamination. These include Johnson and Levine (15), Burton and Rettger (16), Chen and Rettger (17), and Koser (18). Houston (19), and Konrich (20), on the other hand, found from the examination of a large number of soils that the true colon bacilli were rarely found in virgin soil.

Although typical colon organisms have been frequently found on grains and in supposed uncontaminated soils, not so many typical aerogenes organisms (Voges-Proskauer positive, methyl red negative) have been isolated from feces. The following have found very few or no aerogenes cultures in feces: Hulton (21), MacConkey (22), Winslow and Walker (12), Rogers, Clark, and Evans (23), Chen and Rettger (17), Levine (24), Darling (25), and Schobl and Ramirez (26).

The object of the study herein reported was to investigate the correlation of the different tests used for the separation of the colon-aerogenes groups. The study was made on cultures obtained from waters which were collected from widely different sources. The tests used are listed below.

Methyl red test. The methyl red test was conducted as outlined in the "Standard Methods for the Examination of Water and Sewage," sixth edition (3).

Voges-Proskauer reaction. This test was carried out as outlined in the "Standard Methods for the Examination of Water and Sewage," sixth edition, with a slight modification. In addition to making a test at the end of four days, one was also made at the end of two and six days on a large number of the cultures which were recently checked.

Uric acid test. The uric acid medium of Koser was used and readings were made in three, seven, and fourteen days.

Sodium citrate test. The sodium citrate medium of Koser was used. Incubation was at 37°C. and readings were made in three, seven, and fourteen days.

Eosine-methylene blue agar. The medium as modified by Levine (27) was used. A small amount of culture from lactose broth was streaked on the agar. The colonies were observed in forty-eight and seventy-two hours.

SOURCE OF CULTURES

Most of the organisms described in this paper were isolated from waters obtained from widely different sources. A large number of the samples were obtained while the writer was traveling by automobile through different parts of the United States and Canada. The states represented are Colorado, Idaho, Illinois, Indiana, Iowa, Montana, Nebraska, New Jersey, New York, Michigan, Ohio, Pennsylvania, Utah, and Wyoming. Over 300 cultures were obtained from the above sources. Besides these, cultures were obtained from Georgia and Morales (28), Max Levine, S. A. Koser, University of Chicago, and American Type Collection.

EXPERIMENTAL PART

Lactose broth was used as a preliminary enrichment medium. After incubation for twenty-four to forty-eight hours at 37°C., two tubes of each sample showing gas were streaked on eosine-methylene blue agar plates. Characteristic colonies were fished from these plates. Before the permanent slant was made each organism was purified three times by means of lactose broth and streaking on the eosine-methylene blue agar. Each organism was tested for the correlation tests previously discussed—methyl red, Voges-Proskauer, citrate, and uric acid reactions. Tests were made also for gelatine liquefaction, indol, nitrate reduction, acid and coagulation in milk, and fermentations in the usual sugars and alcohols.

The different organisms were divided into groups according to the Voges-Proskauer and methyl red reactions. Of these organisms 195 gave reactions which would place them in what is usually called the colon group, while 164 were in the aerogenes group. Twenty-four

organisms gave irregular reactions. Fifteen of these showed positive reactions for both the Voges-Proskauer and methyl red tests and 9 gave negative reactions for both of these tests.

The organisms were then arranged according to their reactions in sodium citrate and uric acid media and the indol test. Table 1 shows the reactions for the Voges-Proskauer negative and methyl red positive organisms, and also those having a Voges-Proskauer positive and methyl red negative reaction. Table 2 gives the members of the colon group, Voges-Proskauer negative and methyl red positive,

TABLE 1

Organisms arranged to show reactions in different media

TEST	COLON GROUP		AEROGENES GROUP	
	Positive	Negative	Positive	Negative
Uric acid	61	134	155	9
Sodium citrate	44	151	163	1
Indol	148	47	29	135

TABLE 2

Colon organisms arranged to show relationship of tests

NUMBER OF CULTURES	SODIUM CITRATE	URIC ACID
111	−	−
21	+	+
23	+	−
40	−	+

arranged according to the relation of the sodium citrate and uric acid tests.

From tables 1 and 2 it will be seen that the sodium citrate and uric acid tests do not correlate very well with the Voges-Proskauer and methyl red tests, especially for the colon group. Out of 195 organisms 111 showed a negative reaction for both media. The balance, or 43.1 percent, gave a positive reaction for one or both of the test media. The correlation for the aerogenes group was much better. The sodium citrate gave an almost perfect correlation, namely 99.4 percent. The uric acid medium gave 94.5 percent correlation.

Koser (29), together with Koser and Rettger (30), Chen and Rettger (17), Perry and Monfort (31), and Wilson (32), found the uric

acid test to correlate very well with the Voges-Proskauer and methyl red tests. Later Koser (18), as did also Bardsley (33), found the test to be less satisfactory, especially with organisms from unpolluted soils. The sodium citrate test has been found satisfactory by Koser (18), (34), Hicks (35), Lewis and Pittman (36), and Pawan (37), (38). Raghavachari (39) does not consider citrate positive colon organisms to be of non-fecal origin.

Table 3 gives the organisms which showed irregular reactions for the Voges-Proskauer and methyl red tests.

At first it was thought that these irregular organisms were not pure cultures. In most cases, however, these organisms were purified at least fifteen times by streaking on eosine-methylene blue agar. After each purification the Voges-Proskauer and methyl red tests were made. The twenty-four organisms given in table 3 repeatedly

TABLE 3

Reactions for organisms showing irregular reactions for the Voges-Proskauer and methyl red tests

	VOGES-PROSKAUER NEGATIVE; METHYL RED NEGATIVE		VOGES-PROSKAUER POSITIVE; METHYL RED POSITIVE	
	Positive	Negative	Positive	Negative
Uric acid	9	0	11	4
Sodium citrate	9	0	15	0
Indol	1	8	7	8

gave the irregular reactions. There were about twelve other organisms, which at first gave irregular reactions, but after a number of purifications showed normal reactions. It was thought that the Voges-Proskauer test might show better results if run at more frequent intervals. Tests were made on all of the irregular organisms which gave a negative reaction, at the end of one, two, three, four, and five days. There were no changes in the results, however. These abnormal reactions have been reported by a number of different investigators.

Levine (24) has found the correlation of the eosine-methylene agar test to be very satisfactory when compared with the Voges-Proskauer and methyl red tests. Each organism studied in this paper was streaked on eosine-methylene blue plates at least three times. If the appearance of the colonies did not correlate with the other tests,

several additional streaks were made. Tables 4 and 5 list the appearance of the different eosine-methylene blue colonies.

Of the 195 cultures belonging to the colon group listed in table 4, 88.2 percent gave colonies on eosine-methylene blue agar which were distinctly characteristic of true colon colonies. Of the 23 organisms

TABLE 4

Appearance of eosine-methylene blue colonies for colon group

A. True colon colonies	172
B. True colon except no luster	6
C. True colon except larger and no luster	4
D. True aerogenes colonies	7
E. Intermediate	3
F. True colon except irregular shape	3

TABLE 5

Appearance of eosine-methylene blue colonies for the aerogenes group

True aerogenes colonies	157
True colon colonies	1
True colon except no luster	2
Intermediate	3
Aerogenes except had luster	1

TABLE 6

Reactions for colonies of colon group which did not show characteristic reactions on eosine-methylene blue agar

KIND OF COLONY	SODIUM CITRATE TEST		URIC ACID TEST		INDOL	
	Positive	Negative	Positive	Negative	Positive	Negative
B	4	2	3	3	1	5
C	3	1	1	3	0	4
D	6	1	4	3	1	6
E	1	2	1	2	2	1
F	0	3	0	3	0	3

giving irregular colonies, 13 had sufficient characteristics of the colon colony to place them in the colon group with reasonable safety. This would make a correlation of 94.9 percent.

Of the 164 aerogenes cultures there were only 4.3 percent which did not give characteristic colonies. This would give a correlation of 95.7 percent. Levine (24) found the correlation to be higher for the

colon group (96.9 percent) and lower for the aerogenes group (82.4 percent).

The organisms which gave irregular Voges-Proskauer and methyl red tests showed characteristic aerogenes colonies with the exception of three which were Voges-Proskauer and methyl red positive. The latter resembled colon except there was no luster.

It was thought that some information could be obtained by comparing the appearance of the irregular eosine-methylene agar colonies with the other reactions. Table 6 gives this information. The letters used refer to the description of the colonies as given in table 4.

In table 6 none of the groups showed characteristic reactions except groups D and F. Group D gave reactions which, with one exception, were distinctly characteristic of the aerogenes section, whereas group F gave reactions of the colon section.

CONCLUSIONS

1. Over 350 organisms of the colon-aerogenes groups, representing a very wide distribution, have been studied.

2. The correlation of the uric acid test with the Voges-Proskauer and methyl red tests was unsatisfactory for the colon group.

3. The correlation of the sodium citrate test with the Voges-Proskauer and methyl red tests was almost perfect for the aerogenes group and 77 percent perfect for the colon group.

4. Eosine-methylene blue agar medium affords an excellent means of differentiating the colon group from the aerogenes group.

5. A number of organisms exists for which the Voges-Proskauer and methyl red test could not be made to correlate.

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SOCIETY AFFAIRS

PACIFIC NORTHWEST SECTION

The fourth annual meeting of the Pacific Northwest Section was held at Vancouver, B. C., May 14 to 16, 1931. The meeting was attended by 130 members and guests.

At the business meeting held on May 14 the following officers and trustees were elected: *Chairman*, Fred J. Sharkey, Superintendent, Water Department, Wenatchee, Washington; *Vice-Chairman*, Carl F. Klapp, Superintendent, Water Works, Everett, Washington; *Secretary-Treasurer*, Ernest C. Willard, Consulting Engineer, Portland, Oregon; *Trustee*, Alex Lindsay, Superintendent, Water Department, Spokane, Washington; *Trustee* (hold-over), Ray H. Corey, Division Engineer, Public Works Engineering Corporation, Salem, Oregon; *Section Director* (hold-over), W. A. Kunigk, Superintendent, Water Division, Tacoma, Washington.

At this time the Secretary reported the total membership of the Section, including 3 members in Northern Idaho who have transferred to the Pacific Northwest Section from the Rocky Mountain Section, consisted of 67 Active Members, 8 Associate Members and 7 Corporate Members, representing a gain since the last annual meeting which was held in Portland, Oregon, April 24 to 26, 1930, of 14 members.

The meeting opened on May 14 with a Golf Tournament at the Vancouver Golf and Country Club and also with a Round Table Discussion, largely and enthusiastically attended which was held at the Headquarters, Hotel Georgia.

In the evening the business meeting was held, at which time the new officers and trustees were elected and certain amendments to the By-laws of the Section approved. The reports of the Secretary and Treasurer were read and approved, following which an enjoyable instructive address was given by H. V. Gates, President of the Hillsboro Power and Investment Company, entitled "Experiences in the Construction and Operation of Water Supply Systems During the Past Forty Years."

The meeting held on May 15 opened with an address of welcome by the Honorable George C. Miller, acting Mayor of Vancouver to which the response was given by Fred J. Sharkey, Chairman-elect.

This was followed by the following program:

"The Water Supply of Greater Vancouver," by E. A. Cleveland, Chief Commissioner, Greater Vancouver Water District, Vancouver, B. C.

"Problems in Water Rates" by W. A. Kunigk, Superintendent Water Division, Department of Public Utilities. Tacoma, Washington.

"Purification of Water Supplies," by R. G. Tyler, Dean of the College of Engineering, University of Washington, Seattle, Washington.

"Some Aspects of Color Removal as Pertaining to Pacific Coast Water Supplies," by Paul F. Bovard and Kenneth Shibley, California Filter Co., San Francisco, California, and Seattle, Washington.

"Hydrology of Pacific Northwest Streams," by H. S. Rogers, Dean of School of Engineering and Mechanic Arts, and Fred Merryfield, Associate Professor of Civil Engineering, Oregon State College, Corvallis, Oregon.

"Mountain Lake Reservoirs," by W. H. Powell, Engineer, Greater Vancouver Water District, Vancouver, B. C.

In the evening the dinner meeting was held at which time short talks were given by W. A. Kunigk, National Director of the Section and Ernest C. Willard, Secretary-Treasurer. This was followed by an entertainment under the direction of C. Brakenridge, City Engineer of Vancouver, B. C. who was Chairman of the Entertainment Committee.

On Saturday, May 16, an inspection trip was held to the proposed Capilano Intake where luncheon was served through the courtesy of the Greater Vancouver Water District; following which the trip was continued to the Seymour Headworks and dam of the Greater Vancouver Water District.

ERNEST C. WILLARD,
Secretary.

THE FLORIDA SECTION

The second annual short course in water treatment was conducted by the General Extension Division and the Department of Chemistry of the University of Florida in West Palm Beach March 31 and April 1, 1931. The fifth annual meeting of the Florida Section of the Amer-

ican Water Works Association followed on April 2 and 3. The Florida State Board of Health and the Florida Section of the American Water Works Association contributed largely to the success of the short course. Seventy-four men enrolled for the course. This number included plant superintendents, operators, chemists, city managers, sanitary engineers, refrigerating engineers, efficiency engineers, fish hatchery superintendents, well drillers, representatives of manufacturing concerns and staff members of the United States Geological Survey and the Florida State Board of Health. Miss Lena W. Starck of the Florida State Board of Health had the distinction of being the only lady enrolled for the water course.

Dr. A. P. Black, Professor of Chemistry at the University of Florida was chairman of the short course committee and led the instructional staff. Assisting Professor Black were C. B. Pollard, Assistant Professor of Chemistry at the University; H. W. Streeter, Sanitary Engineer, U. S. Public Health Service, Cincinnati, Ohio; E. L. Filby, Chief of Bureau of Engineering, State Board of Health, Jacksonville; Herman Gunter, State Geologist, Tallahassee; A. S. Behrman, Chemical Director, International Filter Company, Chicago; Paul Eaton, Director of Laboratories, Florida State Board of Health; and J. R. Tanner, Chemist, West Palm Beach Water Company.

Registration for the fifth annual meeting of the Florida Section of the American Water Works Association was conducted the morning of April 2 by Secretary E. L. Filby. More than one hundred members presented themselves at the registration desk. On April 2 the officers of the West Palm Beach Water Company tendered a luncheon to the members of the association, a tour of the city which included an inspection of the water works plant and in the evening an entertainment and dance at the Winter Club.

The meeting concluded Friday afternoon with the election of the following officers for 1932: Chairman, F. W. Lane, superintendent of the St. Petersburg water works; Vice-Chairman, L. D. St. Johns, Chief Engineer, Jacksonville city water works; Secretary-Treasurer, E. L. Filby, Jacksonville. Professor Black and M. A. Morris, Chemist, Orlando Utilities Company, were elected to the board of directors to succeed O. Z. Tyler, Jacksonville, and J. O. Lyles, Tampa, whose terms expired.

Among the high lights of the four day session were the following papers: The Bacteriology of Water and Studies of Pollution by H. W. Streeter, Chicago; Preparation of Water for Filtration by Paul Han-

sen, Consulting Engineer, Chicago; and the Use of Activated Carbon for Odor and Taste Removal by A. S. Behrman, Chicago. Beekman C. Little, Secretary of the American Water Works Association, gave a very interesting talk on the affairs of the A. W. W. A.

St. Petersburg was chosen for the 1932 short course and sixth annual meeting of the Florida Section, A. W. W. A.

E. L. FILBY,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Perth, Scotland, Waterworks. Woody Island Scheme. Anon. Water and Water Engineering, **32**: 383, 507–510, November 20, 1930. To avoid contamination by sewage washed back over present intakes at high tide, Perth has built new infiltration collecting system in gravel bank normally dry, two miles upstream on River Tay. Ten culverts branch off in upstream direction from main collecting conduit and receive water percolating through natural sand and gravel. Water is very good chemically and of such bacteriological quality as to require only chlorination. Additional new works include duplicate sedimentation basins ahead of first group of pumps and new reservoir. Steeply sloping ground necessitated long and narrow reservoir, following contour of hillside. Perth supply is most important of pumped supplies in Scotland.—*Arthur P. Miller.*

Waterworks Construction. III. Pipe Laying. M. RATCLIFFE BARNETT. Water and Water Engineering, **32**: 383, 516–520, November 20, 1930. Writer discusses desirability of avoiding abrupt changes in direction and of making curves of as large radius as possible; use of old type spigot and socket curve pipes rather than the newer double socket bevel castings and short pipes; arrangement of inlets and outlets to facilitate largest and easiest inflow and outflow of water; and removal of water from a junction well without turbulence. Article is well illustrated with sketches and photographs.—*Arthur P. Miller.*

Care and Maintenance of Electrical Equipment in the Pumping Station. "Loadfactor." Water and Water Engineering, **32**: 383, 522–524, November 20, 1930. Discusses briefly care and maintenance of electrical equipment, stressing importance of attention to motor bearings; treatment of commutator; and care and fitting of brushes. Chief causes of sparking of brushes and of motor troubles, in order of their frequency, are given.—*Arthur P. Miller.*

The Land Drainage Act of 1930, England, in Relation to River Pollution Prevention. A. BEBBINGTON. Water and Water Engineering, **32**: 383, 525–526,

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

November 20, 1930. Act authorizes drainage boards to prevent obstruction of channels under their control by discharge thereinto of liquid or solid matter. Where no obstruction occurs, this act will be more or less ineffective in preventing pollution. However, with exception of tidal waters, such pollution can be handled by Minister of Health under Rivers Pollution Prevention Act. Drainage act modifies the theory of benefit to extent that all within a catchment area may be required to contribute a fair proportion of cost of maintaining main channels which carry water from that catchment area to the sea. Author hopes that when catchment boards are set up under authority of the act, they will be given power to deal, not only with land drainage, but also with abuse of water courses and with allocation of water supplies.—*Arthur P. Miller.*

Afforestation of Watersheds, England. R. L. ROBINSON. Water and Water Engineering, **32**: 383, 528–529, November 20, 1930. After brief discussion of afforestation as related to water supply and soil utilization, methods by which Forestry Commisson encourages forestry are set forth. They include planting grants, proceeds-sharing schemes, leasing of land from private owners and municipalities, and advice and training of foresters.—*Arthur P. Miller.*

Suction Intakes. G. M. JOHNSON, R. H. GILKEY, et al. Railway Eng. and Maint., **27**: 4, 383–384, 1931. Carefully anchored suction pipes with several joints are recommended for unimportant points. Intake pumps, serving also as settling basins, are effective for large installations.—*R. C. Bardwell.*

Inspection and Maintenance of Water Tanks and Their Appurtenances. E. H. BROWN et al. Railway Eng. and Maint., **26**: 11, 497–500, 1930. Majority of the 27,000 water tanks in service on American railroads are of wood construction, although steel has become more popular of late and a few concrete tanks are in service. Where flat hoops are used on wood tanks careful inspection is necessary. Treated wood tanks require no paint, but others and the steel tanks require repainting about every three years. Precautions should be taken to protect pipes and valves from freezing. Work should be programmed and budgeted.—*R. C. Bardwell.*

Laying Cast Iron Pipe. J. H. DAVIDSON, J. A. CRAWFORD, et al. Railway Eng. and Maint., **27**: 2, 151–152, 1930. Careful inspection of material, care in laying, proper caulking, and avoidance of excessive strains are necessary precautions to minimize danger of later service breaks.—*R. C. Bardwell.*

Freezing of Hydrants. Anon. Railway Eng. and Maint., **27**: 1, 56, 1930. Ample cover and adequate drainage are considered of first importance. Use of manure is suggested in some cases.—*R. C. Bardwell.*

Bottom of Mud Drum Renewed by Welding. Anon. Railway Eng. and Maint., **27**: 4, 369, 1930. Bottom of 6-foot diameter mud drum in elevated steel tank on Chicago Great Western Ry. at Stockton, Ill., cracked beyond repair, was cut from shell by torch. New bottom in halves and cut to fit

around piping was slid under drum shell and welded in place. Repairs required only 8½ hours.—*R. C. Bardwell.*

Blow-off Muffler of Improved Design. Anon. Railway Age, **89**: 24, 1276, 1930. Centrifugal type water and steam separator, located on top of locomotive boiler, ahead of cab, with inlet connection to blow-off cock, steam vent to air overhead, and water discharge to track under engine firebox.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Water Conditioner Shows Savings on the Milwaukee. Anon. Railway Age, **89**: 25, 1321–1323, 1930. Water compartment in front end of engine tank is heated with exhaust steam from cylinders and air pump. Chemical treatment is fed into water inlet where required. Temperature and water level are automatically controlled. Tests show average temperature of 208.6°F. easily maintained and oxygen elimination of 82.4 percent which reduced pitting. Centrifugal boiler feed pump operating at 6000 r.p.m. is likewise automatically controlled.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

New York Central Builds Largest Treating Plant at Elkhart, Ind. Anon. Railway Engineering and Maintenance, **27**: 1, 38–41, 1931. Treating tank 62 feet diameter by 43.5 feet high handles treatment of 150,000 g.p.h. of creek water varying from 12.2 to 15.3 grains per gallon hardness, using lime, soda ash, and sodium aluminate. Unusual features are: duplicate separate feed solution vats, tipping meter control, and four 10.5 foot down tubes from overhead mixing box to provide better distribution and avoid short circuiting currents in sedimentation space.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Results of Water Treatment. T. F. POWERS. Railway Age, **90**: 6, 329–331, 1930. In 1911, Chicago and Northwestern R.R. had one leaky flue failure for each 58,633 locomotive miles. With supervised water treatment, this had been reduced by 1929 to one failure per 4,343,302 miles. Corrosion and pitting still constitute a problem and embrittlement, a potential danger. Properly supervised wayside treating plant has been found most satisfactory method for correcting water quality.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Progress Report Upon the Cause and Extent of Pitting and Corrosion of Locomotive Tubes and Sheets, Giving Consideration to the Quality of Water. J. H. DAVIDSON et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 401, 1931; Bull. **333**. No new methods listed.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Relative Cost of Eliminating Impurities in Locomotive Boiler Waters and the Value of Treatment with Respect to Chemicals and Compounds Applied Direct to Locomotive Boilers and Roadside Tanks, and Conditions Under Which They May be Desirable. C. H. KOYL et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 402–405, 1931; Bull. **333**. Physical condition of sludge formed is important in successful internal treatment of locomotive boiler waters. Chemicals forming large heavy particles are desirable. Limit of 15 grains per gallon of alkali salts is recommended. Good results can be obtained using soda ash,

or proprietary compounds, under careful supervision, the cost varying with quality of water.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Simplification and Standardization of Equipment and Materials Used in Railway Water Service. J. P. HANLEY, et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 406–409, 1931; Bull. **333.** Standardization of railway water service equipment has been retarded, due to variation in manufacturers' products. Attention has been confined largely to pipe, chemicals, and other materials.—*R. C. Bardwell.*

Automatic and Remote Control of Pumping Equipment. J. A. RUSSELL et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 410–414, 1931; Bull. **333.** Reliability is first essential in railway water service and any automatic features must be carefully installed and maintained, including suction and priming arrangements. Many automatic electric stations are in service and tests are being made with automatic gasoline-driven centrifugal pump.—*R. C. Bardwell.*

Protection of Boilers and Boiler Materials from Corrosion and Deterioration While in Storage. D. A. STEEL et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 422–428, 1931; Bull. **333.** Railroads have experienced appreciable corrosion in boiler material while in storage, which later continues to serious extent when material applied and in service. Protective coating with suitable materials and careful handling are recommended.—*R. C. Bardwell.*

Methods of Laying Cast Iron Pipe and Specifications. F. D. YEATON et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 430–438, 1931; Bull. **333.** Final report covers methods and precautions needful and gives specifications for trenching, laying, joints of lead, cement, or substitutes, testing, and back-filing.—*R. C. Bardwell.*

Treats Water Twice in New Plant. R. V. ZAHM. Railway Engineering and Maintenance. **27**: 4, 363–364, 377, 1931. Missouri, Kansas, and Texas R.R. installed complete 30,000-g.p.h. water-softening plant at its Franklin, Mo., terminal in 1929. Lime, soda ash, and sodium aluminate are used to soften and clarify reservoir water ranging from 5.0 to 7.5. g.p.g. in total hardness and from 4.0 to 20.0 g.p.g. in suspended matter. Additional treatments, with alum to neutralize OH and with sodium hypochlorite for sterilization, are given that portion used for drinking purposes with subsequent filtration. Sparling meter is used for lime and soda ash control. Aluminate is added separately by automatic dry feeder. For satisfactory clarification, 6.8 hours was minimum settling time required and 13.8 hours, maximum. Hardness of treated water averages consistently under 1.5 grains per gallon.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Air Conditioning on Passenger Equipment. R. W. WATERFILL. Railway Age, **90**: 4, 233–34, 1931. Air conditioning equipment, being tested in passenger car service and weighing approximately 5 tons, operates by thermostatic control supplemented by hand dampers regulating raw outdoor air. The re-

frigerating apparatus uses Carrene (CH_2Cl_2) and Trieline (C_2HCl_3) which are non-inflammable and safe. Practical air conditioning in railway cars is considered to be in early development stage.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Progress Being Made by Federal and State Authorities on Regulations Pertaining to Drinking Water Supply. A. B. PIERCE et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 429–430, 1931; Bull. **333**. Manual on recommended practice in railway sanitation is being prepared by joint committee of railroad and Public Health Service representatives.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Protection of Water Supply Pipe Line Systems from Electrolysis with Particular Reference to Insulation, Pipe Bonding, Electrical Drainage, and Return Systems. J. J. LAUDIG et al. Amer. Ry. Engr. Assoc. Proceedings, **32**: 415–419, 1931; Bull. **333**. Regular inspections, with tests, are recommended where electrolysis is suspected. Correction may be made by insulation, or by bonding electrical drains where needed.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Chemical Control and General Supervision of Water Treating Plants. R. M. STIMMEL et al. Amer. Ry. Engr. Proceedings, **32**: 419–422, 1931; Bull. **333**. Survey indicates that field inspection is desirable in addition to laboratory check, using field test method for rapid boiler water analysis recommended in A. R. E. A. Manual. Treating plant results should be coördinated with performance of water in locomotive boilers.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Checking Meter Readings. R. H. GILKEY and C. R. KNOWLES. Railway Engineering and Maintenance, **26**: 10, 462, 1930. Standardization and joint check by railway and water company representatives are recommended.—*R. C. Bardwell.*

Preventing Damage to Valves. R. H. GILKEY, L. L. TALLYN, and J. H. DAVIDSON. Railway Engineering and Maintenance, **26**: 11, 516–517, 1930. Care in installation, avoiding excessive pressure in closing, periodic operation, and proper maintenance are recommended.—*R. C. Bardwell.*

Spacing Coach Yard Hydrants. R. C. BARDWELL, C. R. KNOWLES, and R. H. GILKEY. Railway Engineering and Maintenance, **26**: 12, 561–562, 1930. Coach yard hydrant spacing should not exceed 100 feet and hydrants should be located at least 7 feet from center of track.—*R. C. Bardwell.*

Boiler Tube Corrosion Halted by Hot Process Treatment. R. E. COUGHLAN. Railway Age, **89**: 17, 855–856, 1930; Railway Engineering and Maintenance, **26**: 12, 550, 1930. Chicago and Northwestern R.R. eliminated serious pitting in six 500-h.p. water tube boilers using Chicago city water, by installation in 1928 of hot process softener using lime, soda ash, and sodium aluminate, replacing unsatisfactory internal treatment.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Lump or Hydrated Lime? O. T. REES et al. Railway Engineering and Maintenance **27**: 3, 276–278, 1931 and 4, 385. Available CaO for use in water treatment can be obtained in lump lime at first cost as much as 55 percent lower than in hydrated lime. However, rapid deterioration of lump lime in shipment and storage affects its reliability and where more uniform results and greater accuracy of treatment are required, together with greater ease of control, use of hydrated lime is favored.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Double Filtration of Water. S. WALKER. British Waterworks Assoc., 1931, **13**: 91, 65–66. Experiments with primary sand filters in which coarser sand than is customary was used have caused Metropolitan Water Board (London) to build primary filters at Kempton Park to render water suitable for treatment at increased rate on existing sand filters. Filters have been working most satisfactorily since November, 1929; rate at which water is filtered has been increased threefold; capital expenditure that would have been required for extension has been reduced by 55.7 percent; and saving of £145,000 ($725,000) has been effected; while there is considerable saving in working costs owing to reduced number of sand washings of secondary beds.—*W. G. Carey.*

Rural Water Supply Problem. D. F. WORGER. British Waterworks Assoc., 1931, **13**: 91, 62–63. Water supplies for rural districts are localized and cost of mains etc., reduced by causing automatically controlled pumping plant to deliver water into sealed cylindrical tanks. These tanks are situated on discharge pipes from pumps to mains, and are kept about two-thirds full of water against an air pressure equal to that which it is desired to maintain in mains. When water is drawn from mains, air volume in tanks increases and pressure begins to fall, operating automatic mechanism and starting the pumps, which are automatically stopped when pressure rises again to upper limit. By this means cost of service reservoirs and water-towers is avoided and working expenses are reduced to a minimum.—*W. G. Carey.*

Volumetric Determination of Sodium. A. BLENKINSOP. Jour. Agric. Sci., **22**: 511–516, 1930. From Analyst, **56**: 134, 1931. Solution containing not more than 0.012 gram sodium as chloride is evaporated and 15 cc. are added of mixture of solution of 10 grams uranyl acetate in 6 cc. acetic acid and 60 cc. water with solution of 30 grams zinc acetate in 3 cc. acetic acid and 32 cc. water. Precipitate is filtered, dissolved in HCl, and uranium reduced by excess 0.02 N titanous chloride; excess is determined by titration with iron alum solution in presence of 20 cc. 2 percent hydrofluoric acid and 10 cc. 10 percent potassium thiocyanate until permanent red colour is produced. One cubic centimeter 0.02 N titanous chloride equals 0.0000767 gram sodium.—*W. G. Carey.*

Base Exchange Properties of Clays. G. WIEGNER. Chemistry and Industry, **50**: 8, 65–70 T, February 20, 1931. Permutits and clays with exchange properties are micelles consisting of an ultramicron, an inner layer of anions, and an outer swarm of cations. The ultramicron may contain silicic acid and aluminium hydroxide in varying proportions; the more silicic acid, the greater is the base exchange, up to a certain maximum, because then the inner layer

consists mainly of silicic acid anions from which the cations of the outer swarm dissociate more readily than from inner layer hydroxyl ions united to aluminium. Opposite the inner layer of anions is held the swarm of cations by attraction which is the more powerful the less their hydration and the greater their valency. Bivalent ions enter more readily than univalent, at comparable hydrations. Magnesium is less displaced by exchange and enters by exchange less readily than calcium, strontium, or barium. The ionic exchange determines the electrical potential of the micelles, and also their behaviour in coagulation.—*W. G. Carey.*

Mechanism of Activated Sludge Process. E. C. C. Baly. Chemistry and Industry, **50**: 3, 22–26 T, January 16, 1931. Sewage colloids have isoelectric point at about pH 4.6 which is shifted towards side of greater pH in presence of electrolytes. The colloids are electropositive in solutions more acid than that corresponding to the isoelectric point and electronegative in those more alkaline. The colloids in ordinary sewage with pH 7.4 are therefore electronegative (cf. Buswell and Long, J. A. W. W. A., 1923, **10**: 309). Bacteria of sewage are electronegative and, when their concentration is sufficient, are flocculated by electropositive colloids. The colloids may be rendered electropositive by adding 3 percent of sodium chloride to sewage and mixing therewith a cream of clay or fine silt.—*W. G. Carey.*

Direct Nesslerisation of Ammonia in Sea Water. H. Wattenberg. Pharmaceutical Jl., **126**: 11, 1931. Precipitation of calcium and magnesium is prevented by addition of 5 cc. of 30 percent solution of Rochelle salt to 100 cc. of sample; 10 cc. of 20 percent sodium hydroxide and 2 cc. of Nessler's reagent are then added and color compared with standards after standing.—*W. G. Carey.*

Prevention of Scale in Boilers. E. S. Davies. British Waterworks Assoc., 1931, **13**: 91, 65. An electrostatic method is to pass a small current (0.1 kw. per hour) through the boiler (not the water) at a few millivolts pressure. Boiler acts as hollow conductor in closed electrical circuit and brings to its own polarity water and impurities. Particles in water are repelled instead of being attracted to tubes, and salts are deposited loosely at base of boiler.—*W. G. Carey.*

The Safety of Reservoirs Act 1930 (Britain). Engineer, **151**: 33, 1931. Panels of engineers chosen by Ministry of Health and Institution of Civil Engineers have been set up for designing, supervising construction, and inspecting the safety of large reservoirs. Forms, certificates, and reports are prescribed and Local Authorities, or others interested, in any area likely to be affected by escape of water are entitled to inspect these reports and certificates. If requirements of Act have not been complied with, penalty of £500 ($2500) may be imposed; while fact that reservoir has been constructed according to Act does not exonerate from blame in case of accident.—*W. G. Carey.*

Sixty-Third Annual Report of the Commissioners of Water Works in the City of Erie, Pa., for the Year Ending December 31, 1929. 92 pp. In addition to

the usual admirable tabulations of operating statistics, brief data are included this year on the projected extension to the water supply system, together with brief comments on the purification problems encountered. A bond issue of $1,700,000 for the construction of an additional intake, pumping station, and filter plant was approved at a special election in July. A contract has been let for the construction of a new 72-inch riveted steel intake pipe of 70-m.g.d. capacity, 8800 feet long, and plans are well under way for the pumping station and filter plant. The plant will be designed for an initial capacity of 16 m.g.d., and an ultimate capacity of 70 m.g.d. The Commissioners have contracted with the city to meet all maturities and expense in connection with the bond issue out of current revenue. An appraisal of plant assets as of January 1, 1930, showed a sound value of fixed assets of $9,349,058.57. The average daily consumption during the year was 25,655,378 gallons, an increase of 1,539,269 gallons over 1928. The estimated population supplied is 127,000. The respective per capita consumption averages, inclusive of and exclusive of the water supplied through meters, were 202.01 and 111.62 gallons per day. There are now 31,506 services, of which 1130 (3.587 per cent) are metered. The net addition to the surplus during the year was $155,900.41, exclusive of water supplied for public use, without remuneration, to the value of $59,970.67. The cost of collecting, purifying, and pumping the water, including depreciation, was $26.401 per million gallons. The number of gallons of water pumped averaged 296.49 per pound of coal consumed. The average amounts of alum and hypochlorite used were 0.288 grains per gallon and 4.0 pounds per million gallons, respectively. The wash water averaged 2.47 per cent of the water filtered. Of 300 1-cc. samples of raw water examined for *B. coli*, 156 gave positive results, while of 605 10-cc. samples of filtered water examined, none contained the colon bacillus. The intake is located 1 mile from shore in 35 feet of water. Storms, under certain conditions, increase the turbidity to considerably over 100 p.p.m. within a period of a few hours, and at times the water is heavily polluted with sewage. Trade wastes are also present at times, but this type of pollution has been reduced to a minimum through the coöperation of the local manufacturers. Arrangements have been completed for the installation of special equipment for the prevention of taste due to industrial wastes and it is hoped that this equipment will also aid in elimination of tastes due to algae growths, which were troublesome during the past year. The method of taste elimination to be employed is not disclosed. The usual brief description of works and schedule of rates is included.—*R. E. Thompson.*

The New McTavish Pumping Station in Montreal, Quebec. C. J. DESBAILLETS. Cont. Rec. and Eng. Rev., **44**: 385–8, April 2, 1930. An illustrated description of the new McTavish pumping station now nearing completion in Montreal, which forms part of the scheme for amalgamating the system of the Montreal Water and Power Co., acquired in 1928, with the city system. The pumping units are of the two-single-stage type arranged in series and driven by self-starting synchronous motors, 3 being of 12 m.g.d. capacity and 3 of 15 m.g.d. The McTavish St. reservoir, in which all the pumps will have their suction, had a capacity of 40 million gallons. The reservoir was excavated in solid rock and is partitioned into 2 basins. As there had been some loss

through seepage during recent years it was decided to pave the bottom and waterproof the walls. The pavement is a 6-inch slab reinforced with "Steelcrete." Expansion joints of ¼-inch "Minwax" give panels about 20 by 30 feet. The pavement was carried up the walls for 5 feet and the balance of the walls tightened with gunite. The capacity of the reservoir was increased 7 million gallons by excavation and by raising the retaining walls 2 feet. The architecture of the building is Scotch baronial gothic, to conform with buildings in the vicinity.—*R. E. Thompson.*

Sterilization of Sea Water by Means of Chlorine. D. R. Wood and E. T. Illing. Analyst, **55**: 126–7, 1930. From Chem. Abst., **24**: 2219, May 10, 1930. In connection with swimming pools, the question has arisen as to whether the addition of bromine would serve as well as chlorine. Experiments indicate that bromine is at least as efficient as the equivalent weight of chlorine and is no more objectionable to the eyes and tongue.—*R. E. Thompson.*

Lead Pipes Embedded in Cement and Lime Mortar. Atilio A. Bado. Añales asocn. quim. Argentina, **17**: 5–12, 1929. From Chem. Abst., **24**: 327, January 20, 1930. Severe corrosion of lead pipe recently placed in lime-sand mortar and in concrete has been encountered. The pipe contained only 0.5 percent impurities. It was not attacked in moist soil. Analyses of corroded scale showed following percentage composition:—lead, 79.65; iron, 0.05; tin, trace; CO_2, 13.20; chloride, 1.06; silica and silicates, 1.50; water at 100–5°, 0.85; combined water at 180°, 3.69. A suggested cause of corrosion is reaction $2CO_2 + H_2O + O + Pb = Pb(HCO_3)_2$. Latter, in presence of calcium hydroxide from cement or mortar, produces lead hydroxide. Presence of lead oxides is difficult to explain. Corrosion can be prevented by embedding pipe in clay, or by coating it with pitch or tar.—*R. E. Thompson.*

Protecting Lines Against Corrosion. G. N. Scott. Oil and Gas J., **28**: 17, 37, 157–8, 1929. From Chem. Abst., **24**: 579, February 10, 1930. Factors that control soil corrosion of a pipe line throughout its length are so complex as to require that subject be coöperatively studied in order to find economical measures of prevention. American Petroleum Institute and Bureau of Standards have been collecting data.—*R. E. Thompson.*

A Comparison of the Corrosion-Resistant Properties and Electrical Resistance of Materials Used for Protecting Iron Pipe. W. Beck and K. Jacobsohn. Korrosion Metallschutz, **5**: 202–7, 1929. From Chem. Abst., **24**: 578, February 10, 1930. Insulating properties of some protective materials are rapidly reduced upon immersion of the covered pipe in sea water, conductivity water, water saturated with calcium sulfate, or soil moistened with conductivity water. The corrosion-resistant properties are not changed appreciably upon immersion; yet against electrolytic corrosion they do not prove effective. In acid waters the corrosion protection is reduced materially.—*R. E. Thompson.*

Formation of Scale in the Steam Boiler. M. Berger. Allgem. Österr. Chem.-Tech.-Ztg., **47**: 149, 1929. From Chem. Abst., **24**: 673, February 10, 1930. A general article.—*R. E. Thompson.*

The Stratified Settling of Fine Sediments. P. G. NUTTING. J. Wash. Acad. Sci., 19: 402–6, 1929. From Chem. Abst., 24: 540, February 10, 1930. A theory of the settling of fine sediments is presented that is simpler and more general than EINSTEIN'S, gives PERRIN'S law of distribution as a special case, and covers stratified settling adequately.—*R. E. Thompson.*

Carbon Monoxide Poisoning While Welding a Pipe. L. SCHWARZ. Zentr. f. Gewerbehyg. und Unfallverhütung, 16: 111–5, 1929; Gas-u. Wasserfach, 72: 1056. From Chem. Abst., 24: 575, February 10, 1930. Carbon monoxide poisoning of men working inside of a pipe during welding was found to be due to burning of the bituminous coating. This was prevented by not using the coating for a length of 12 inches from each end of the pipe, and by using oxygen masks or those giving protection against carbon monoxide.—*R. E. Thompson.*

The Use of Ozone in Purifying Water and in Food Manufacture. JONATHAN SHARP. Food Industries, 1: 625–7, 1929. From Chem. Abst., 24: 673, February 10, 1930. An automatic water ozonizer is described. The apparatus was very effective in sterilizing water as well as in removing chlorophenol and leafy taste. Commercial equipment of capacities ranging from 100 to 10,000 gallons per hour are figured.—*R. E. Thompson.*

Chlorine Demand and Bactericidal Action of Chlorine in the Sterilization of Drinking Water. VICTOR FROBOESE. Gesundh. Ing., 52: 791, 1929. From Chem. Abst., 24: 673, February 10, 1930. The determination of the chlorine demand of water is of value. The chlorine demand of water acidified with hydrochloric acid is less than that of the unacidified water. After addition of an excess of chlorine to water, almost all of the chlorine demand is satisfied in 10 minutes. If chlorine demand is low, good sterilization of water is shown in a short time, if excess of chlorine is present.—*R. E. Thompson.*

Disappearance of Phenol in Water. H. BACH. Gesundh.-Ing., 52: 796, 1929: cf. C.A., 23: 1192. From Chem. Abst., 24: 673, February 10, 1930. Fish were placed in water containing 10 p.p.m. of phenol. The phenol disappeared and additional phenol was added to keep the quantity constant. Of 15 fish placed in water containing phenol up to 15 p.p.m., 12 fish were living after 46 days. The fish were killed then and cut open. A weak odor of phenol could be detected in the fish.—*R. E. Thompson.*

The Harmful and Useful Action of Domestic and City Sewage on Fisheries. A. SCHILLINGER. Gesundh. Ing., 52: 738, 1929. From Chem. Abst., 24: 673, February 10, 1930. Fish can be grown in partially purified sewage, as large quantities of fish food are available in such material. The oxygen content of the water must be controlled carefully.—*R. E. Thompson.*

The Neutralization of Acid in Wastes with Carbonates. A. HEILMANN. Gesundh.-Ing., 52: 787, 1929. From Chem. Abst., 24: 673, February 10, 1930. The value of carbonates in neutralizing the acidity of waste waters and in precipitating colloidal matter by changing the pH is shown.—*R. E. Thompson.*

The Oligodynamic Action of Silver. RAOÚL WERNICKE and FERDINAND MODERN. Biochem. Z., 214: 187–97, 1929. From Chem. Abst., 24: 879, February 20, 1930. Distilled water which upon contact with metallic silver displays an oligodynamic action contains this metal in solution in ionized condition in a concentration of about 0.00005 milligram per cc. Distilled water oligodynamically activated by contact with metallic silver completely loses this effect upon prolonged electrolysis, whereby a precipitate of silver is found at the cathode. The bactericidal action of solutions containing silver or copper is exerted in the presence of hydrogen without oxygen, which is only necessary for the oligodynamic activation through contact with the metals.—*R. E. Thompson.*

Detection of Fluorine in Mineral Waters. J. CASARES GIL. Añales soc. españ. fís. quím. (tecnica), 27: 141–3, 1929. From Chem. Abst., 24: 907, February 20, 1930. Five hundred cc. of mineral water and a little barium chloride are concentrated, acetic acid is added and the mixture evaporated to dryness. The residue is extracted with water, the remainder placed in a porcelain crucible with a little silica and concentrated sulfuric acid and covered with a glass on the lower surface of which is a drop of water. Silicon fluoride evolved on heating is dissolved and decomposed by the water, showing silica formation.—*R. E. Thompson.*

Broad Weir Baths and Wash-houses, Wellington-Road, St. Matthias, Bristol (England). H. W. HARDING. Munic. Eng. Sanit. Record, 83: 440–1, 1929. From Chem. Abst., 24: 908, February 20, 1930. The water in the pool, which has a capacity of 70,000 gallons, will be circulated every 4 hours and will be purified by means of pressure filters, aëration, chlorination, etc.—*R. E. Thompson.*

Water Softening, the Base-Exchange, or Zeolite Process. A. R. MARTIN. Dept. Sci. Ind. Research, Tech. Paper No. 1, 20 pp., 1929. From Chem. Abst., 24: 906, February 20, 1930.—*R. E. Thompson.*

Chemical Attacks on Iron. AM. MATAGRIN. La Nature, 57: II, 212–8, 1929. From Chem. Abst., 24: 813, February 20, 1930. A description of the various forms of iron corrosion.—*R. E. Thompson.*

Corrosion Resisting Ferrous Alloys. AM. MATAGRIN. La Nature, 57: II, 354–60, 1929. From Chem. Abst., 24: 813, February 20, 1930. A review of the alloys recently developed.—*R. E. Thompson.*

The Problem of Ferrous Metal Corrosion. V. SALLARD. Tech. moderne, 21: 673–81, 1929. From Chem. Abst., 24: 813, February 20, 1930. A résumé of the causes of corrosion and of the properties of the different alloys developed to resist these reactions.—*R. E. Thompson.*

Attainment of Durability in Concrete Structures. JOHN F. HOUGH. Eng. J. Canada, 12: 617–25, 1929. From Chem. Abst., 24: 939, February 20, 1930.

Data are given for establishing a direct relation between the water-cement ratio and some required degree of durability.—*R. E. Thompson.*

Principles of the High-Pressure-Cylinder Testing. GLEN D. BAGLEY. Compressed Gas Mfrs.' Assoc., Sixteenth Ann. Rept. 1928, 55–68. From Chem. Abst., **24**: 993, March 10, 1930. Simple, mechanical, non-destructive tests are available which make it possible to determine the wall thickness and condition of the steel on every cylinder placed in service. The hammer test is to be repeated frequently.—*R. E. Thompson.*

The Anomaly of Water. II. WITOLD (JACYNO) JAZYNA. Z. Physik, **58**: 429–35, 1929. From Chem. Abst., **24**: 1006, March 10, 1930. The anomaly presented by water between 0° and 4° is explained by assuming that melting is not complete at 0° and 760 mm. Only 98.3 percent of the solid melts. Between 0° and 30°, crystals of ice are suspended in the liquid as an emulsion which is destroyed progressively as the temperature increases.—*R. E. Thompson.*

The Hydrogen Exponent (pH) of Water. A. KLING and A. LASSIEUR. Compt. rend., **189**: 637–9, 1929; cf. C.A., **20**: 854, 1161. From Chem. Abst., **24**: 1012, March 10, 1930. The authors have previously reported that the pH of pure water is 5.8. This value was substantiated by 2 more sets of measurements. The e.m.f. of the cell hydrogen/water, mercurous chloride/mercury was measured with a quadrant electrometer. The results indicate a pH of 5.6. The e.m.f. of a cell composed of 2 hydrogen electrodes containing, respectively, pure water and buffered solutions, the latter varying from 5.2 to 6.2 was measured. The cell containing a buffer with a pH of 5.8 showed zero potential. Many precautions were taken in selecting the glass, washing the electrodes, and establishing equilibrium. Water is not a neutral solvent.—*R. E. Thompson.*

Corrosion Fatigue. An Explanation of Boiler-Plate Failure. H. C. DINGER. Power, **71**: 133–4, 1930. From Chem. Abst., **24**: 1069, March 10, 1930. Defective workmanship is responsible for most boiler failures. Corrosion is usually only a minor contributing factor.—*R. E. Thompson.*

What Colloids Are and Their Place in Boiler-Water Conditioning. GEORGE C. REINHARD. Power, **71**: 73, 1930. From Chem. Abst., **24**: 1170, March 10, 1930. Colloids used for boiler water conditioning should be capable of forming by coagulation a gel which is stable under boiler conditions.—*R. E. Thompson.*

Alignment Chart for Calculating Alkalinity in Boiler Water. E. A. WADE. Power, **70**: 1041, 1929. From Chem. Abst., **24**: 1170, March 10, 1930. From titer of the sample with 0.05 *N* sulfuric acid, to phenolphthalein and methyl orange end points, the chart gives values for causticity and carbonate alkalinity.—*R. E. Thompson.*

Determination of Oxygen in Flood Water Polluted with Sewage. L. W. HAASE. Gesundh.-Ing., **52**: 846, 1929. From Chem. Abst., **24**: 1170, March

10, 1930. The WINKLER method for determining dissolved oxygen in water containing reducing substances, such as sulfite liquors, is not accurate. This is a preliminary report.—*R. E. Thompson.*

Chemical and Bacteriological Studies of Sewage. K. L. PESCH and E. SAUERBORN. Gesundh.-Ing., **52**: 856, 1929. From Chem. Abst., **24**: 1170, March 10, 1930. The BACH method for determining the oxygen content of water compared favorably with the WINKLER and modified WINKLER methods. Aëration of polluted water causes a decrease in the bacterial count of pathogenic organisms present.—*R. E. Thompson.*

Water Treatment for Diesel Plants. L. A. PEASE. Power, **71**: 101, 1930. From Chem. Abst., **24**: 1169, March 10, 1930. A zeolite softener suitable for a Diesel plant is described.—*R. E. Thompson.*

Arizona State Board of Health, Bulletin **50: 1929.** From Chem. Abst., **24**: 1168, March 10, 1930. **Phoenix Water Supply.** W. J. JAMIESON. 29–32. Verde River water is obtained through infiltration galleries. Consumption is 167 gallons per capita per day. **Yuma Water Supply.** FRED C. LYNES. 38–9. Is derived from the Colorado River; purification plant consisting of settling basins, slow sand filters, and chlorination apparatus. A filter washer is employed. **Water Supplies of the Santa Fe Railway in Northern Arizona.** G. L. DAVENPORT. 33–5. Desert water problems are discussed.—*R. E. Thompson.*

Potable Waters. MANUEL DE SARRIA. Quim. ind., **6**: 81–7, 1929. From Chem. Abst., **24**: 1169, March 10, 1930. The Spanish royal decree of 1920 gives the limits: fixed residue at 180°, 500 mg.; fixed residue after calcination, 450 mg.; chlorides as sodium chloride, 60 mg.; calcium as calcium oxide, 150 mg.; sulfuric acid as SO_3 50 mg.; all per liter. Relation of mineral constituents of water to health is discussed. Other standards of purity are also considered. —*R. E. Thompson.*

Oligodynamic Sterilization of Drinking Water by the Katadyn Process. F. KONRICH. Gesundh.-Ing., **52**: 804, 1929. From Chem. Abst., **24**: 1169, March 10, 1930. A review of present knowledge of oligodynamics. Time is a very important factor in sterilization by this process.—*R. E. Thompson.*

Water Softening Plants on the Great Southern Railways of Ireland. Engineer, **149**: 103–4. From Chem. Abst., **24**: 1446, March 20, 1930. Four plants of the Lassen-Hjort type are described.—*R. E. Thompson.*

Chlorinating Circulating Water Keeps Condensers Clean. V. M. FROST and W. F. RIPPE. Power, 70: 961–3, 1929. From Chem. Abst., **24**: 1169, March 10, 1930. Addition of 1 or 2 p.p.m. of chlorine to polluted river water prevented slime formation. There was a gain in vacuum and condensers required less cleaning.—*R. E. Thompson.*

The Use of Ammonium Chloride-Citrate Agar for Identification of Coli Bacteria in Water and Sewage. K. L. PESCH. Gesundh.-Ing., **52**: 884, 1929.

From Chem. Abst., **24**: 1170, March 10, 1930. *B. coli* of fecal origin do not grow in a synthetic medium containing ammonium chloride and citric acid. Such a medium is of value in distinguishing bacteria of this group—*R. E. Thompson.*

Swimming Pool Sanitation at the University of Iowa. JACK J. HINMAN, JR. Proc. Iowa Acad. Sci., **35**: 98, 1928. From Chem. Abst., **24**: 1170, March 10, 1930. The quality of swimming pool waters, being liable to very rapid fluctuation, must be closely watched. It is best to depend upon filters for clarification; gravity filters have been found more satisfactory than pressure filters, on account of the cementing action of calcium salts upon sand. A residual chlorine content of 0.2 p.p.m. is essential to proper germicidal treatment, for which a dosage between 0.2 and 0.5 p.p.m. is needful.—*R. E. Thompson.*

Water and Its Relation to the Textile Industry. WM. H. MITCHELL. Proc. Am. Assoc. Textile Chem. Colorists 1929, 311–9; Am. Dyestuff Reptr., **18**: 611–9, 1929. From Chem. Abst., **24**: 1221, March 10, 1930. Hardness interferences in the various processes of the textile industry are detailed. Purification with alum and lime-soda is mentioned and softening with zeolite is discussed in detail.—*R. E. Thompson.*

A New Purification System for Textile Mill Water. J. BECKER. Melliands' Textilber., **10**: 379–80, 1929. From Chem. Abst., **24**: 1447, March 20, 1930. Apparatus is described for removing calcium, magnesium and colloidal material by combined electrolysis and electroösmosis. The process is cheap and effective.—*R. E. Thompson.*

Some Permeability Studies of Concrete. F. R. MCMILLAN and INGE LYSE. J. Am. Concrete Inst., **1**: 101–42, 1929. From Chem. Abst., **24**: 1195, March 10, 1930. The experimental apparatus and its use are described by means of which the permeating water is measured. The test is very sensitive, even to minor defects in the concrete specimen. Indications are that, in service, placing of the concrete is more important than any ordinary differences in materials or proportions. During the earlier periods of moist curing, increase in water-tightness is rapid; there is practically no further increase after removal to air of laboratory. Increase in water-cement ratio is accompanied by a reduction in water-tightness for any condition of test. With different cements, rate of development of water-tightness parallels rate of development of compressive strength. Admixtures which require use of extra water in the concrete to maintain plasticity reduce water-tightness, while those which do not effect a slight improvement.—*R. E. Thompson.*

Disintegrations of Concrete. Report of Committee 803. G. M. WILLIAMS, et al. J. Am. Concrete Inst., **1**: 41–56, 1929. From Chem. Abst., **24**: 1195, March 10, 1930. Review of available knowledge of effects of weathering, exposure to "alkali" waters, and protection of concrete against deterioration from these influences.—*R. E. Thompson.*

Disintegration of Concrete in Hydraulic Constructions. BROS. SJÖGREN. Tek. Fören. I Finland Förh., **49**: 226–9, 1929. From Chem. Abst., **24**: 1484, March 20, 1930. Abstract of report of the Swedish water power commission on damage to concrete in hydraulic constructions. The chief results are: (1) clean sand gives a water-tight concrete only with a mixture strength greater than 1:2:2.5, and then only with correct water addition; (2) a slight humus content makes an acceptable mix; (3) pyrites and mica do not seem to be detrimental; (4) natural clayey or calciferous sands seem comparable with clean sand; (5) cement from rotary ovens appears to be as satisfactory as special cements; (6) talc and similar fillers do not improve the concrete; (7) slaked lime up to 10 per cent of the cement is beneficial; (8) The addition of 3 per cent calcium chloride does not affect the water-tightness; (9) with clean sand which gives more than 50 percent particles of diameter less than 0.5 mm., a tight concrete may be made with a 1:4.5 mix; (10) silica and oxalic acid have proved very beneficial when added to the cement.—*R. E. Thompson.*

α-Naphthoflavone as Indicator in Iodometry. J. F. REITH. Pharm. Weekblad, **66**: 1097–1110, 1929. From Chem. Abst., **24**: 1312, March 20, 1930. Starch has certain disadvantages in titration of very dilute iodine solutions. α-Naphthoflavone gives a color reaction about 5 times as sensitive and will detect 0.005 mg. free iodine in 100 cc. The indicator (0.5 cc. of a 1 per cent solution in ethyl alcohol) is added to 100 cc. of the solution, which has been made 0.1 N with sulfuric acid, and the titration performed with 0.001 N sodium thiosulfate. In the absence of iodine, the initial color is blue and the end point, colorless; in its presence, initial color is brown and end point, violet. Corrections, which vary with the potassium iodide content of the solution, are given in a chart. Determinations may also be made colorimetrically by comparing the intensity of color with a known standard. The method has possibilities for the determination of free chlorine in drinking water.—*R. E. Thompson.*

Stability of Tenth-Normal Sodium Chloride Solution, and Certain Other Questions Relating to Volumetric Analysis. VASTERLING. Pharm. Ztg., **75**: 58–9, 1930. From Chem. Abst., **24**: 1312, March 20, 1930. Statements to the contrary notwithstanding, 0.1 N solutions of sodium chloride 10 years and more old are shown to have suffered little or no loss of titer with age, if kept in properly sealed containers.—*R. E. Thompson.*

The Composition of Rain Water of Rio de Janeiro. HASSELMANN DJALMA. Rev. bras. chim., **1**: 51–2. 1929. From Chem. Abst., **24**: 1443, March 20, 1930. Results of analyses of 10 samples of rain water from various places in city of Rio de Janeiro are given. Author attributes complete absence of nitrates and ammonia to long interval between collection and analysis of samples.—*R. E. Thompson.*

Corrosion Phenomena on a Cast Iron Service Pipe Line Subjected to the Action of Mineral Waters at Various Locations. F. ENSSLIN and FR. BUSCHENDORF. Korrosion Metallschutz, **5**: 227–30, 1929. From Chem. Abst., **24**:

1330, March 20, 1930. A cast iron soil pipe corroded at a bend was found to have a layer of incrusted mineral matter on the outside surface. The inside was almost unaffected by corrosion. The pipe failed at a joint, due to electrolytic action of lead-iron couple in the highly mineralized ground water.—*R. E. Thompson.*

Corrosion of Metals and Its Prevention. H. E. YERBURY. Proc. Inst. Mech. Eng. (London) 1929, No. 3, 545–58. From Chem. Abst., **24**: 1331, March 20, 1930. Review of the existing electrolytic theory of corrosion from the viewpoint that materials not in a state of equilibrium must tend towards that state with accompanying energy change. Several instances of corrosion and erosion normally encountered in water, soil, boilers, etc., are discussed with reference to choice of metal or alloy for use in specific cases. Methods of corrosion prevention, such as alloying, e.m.f. application, painting, or wrapping, are discussed, with examples of their applicability.—*R. E. Thompson.*

Corrosion and Metal Protection in Boiler Operations. II. R. STUMPER. Korrosion Metallschutz, **5**: 230–5, 1929; cf. C.A., **23**: 1097. From Chem. Abst., **24**: 1330, March 20, 1930. Author lists the corrosion processes possible in boilers. Corrosion resulting from boiler scale is attributed to overheating and direct chemical action following thermal decomposition of the scale with liberation of corrosive substances at the metal surface. It is assumed that a liquid layer exists between scale and metal as result of diffusion through pores of scale.—*R. E. Thompson.*

Recent Development in Corrosion- and Heat-Resisting Steels. ROBERT HADFIELD, T. G. ELLIOT and R. J. SARJANT. J. Soc. Chem. Ind., **49**: 41–51T, 1930. From Chem. Abst., **24**: 1330, March 20, 1930.—*R. E. Thompson.*

Additional Information on the Corrosion of Brass. HANS MASUKOWITZ. Korrosion Metallschutz, **5**: 217–26, 1929. From Chem. Abst., **24**: 1331, March 20, 1930. Review of the literature on the uses and corrosion resistance of various brasses under different conditions from the viewpoints of type of alloys, grain size, heat treatment, and working. A tabulated summary of the findings of many investigators is given.—*R. E. Thompson.*

Birmingham (England) Waterworks. More Recent Developments. J. W. WILKINSON. Munic. Eng. Sanit. Record, **83**: 578–9, 1929. From Chem. Abst., **24**: 1443, March 20, 1930. Some problems of construction and maintenance of water mains are discussed.—*R. E. Thompson.*

Algae in Water Supply. Control by Chlorination. Munic. Eng. Sanit. Record, **83**: 526, 1929. From Chem. Abst., **24**: 1445, March 20, 1930. Taking advantage of rotation set up by sluice gates, the entire body of water in a reservoir containing from 4 to 13 million gallons was thoroughly treated with a known dosage of gaseous chlorine thrice weekly at night during the summer. This replaced the use of blue vitriol, applied from a boat, and the tedious and clumsy application of chlorine from a floating outfit. The treatment was effec-

tive in destroying organisms and no complaint was received from consumers. —*R. E. Thompson.*

Studies of the Sea Water Near the Puget Sound Biological Station During the Summer of 1927. THOMAS G. THOMPSON, ROBERT C. MILLER, GEO. H. HITCHINGS and SELDON P. TODD. Pub. Puget Sound Biol. Sta., **7**: 65–99, 1929. From Chem. Abst., **24**: 1446, March 20, 1930. A discussion is given of the CO_2-HCO_3^--$CO_3^=$ equilibrium in sea water. The lack of close correlation between pH values and those for carbon dioxide and dissolved oxygen is attributed to the complexity of the system, and to the fact that equilibrium is seldom, if ever, attained in the sea; hence data obtained in the laboratory indicating that pH, carbon dioxide, and titratable alkalinity can be represented as straight-line functions do not apply to sea water *in situ*. Titrimetric methods are not applicable to the determination of carbon dioxide in sea water.—*R. E. Thompson.*

Recent Developments in the Purification and Treatment of Feedwater. CHARLES L. HUBBARD. Textile World, **76**: 1315–9, 1929. From Chem. Abst., **24**: 1446, March 20, 1930. Article deals with innovations in treatment, control methods, and boiler operation. Evaporators, deconcentration appliances, deaërators, electrolytic scale and corrosion prevention systems, methods for inhibiting embrittlement, and steam purifiers are discussed and illustrated. —*R. E. Thompson.*

Technical Aspects of the Prevention of Pollution of Rivers by Domestic Sewage and Trade Wastes. ARTHUR J. MARTIN. Munic. Eng. Sanit. Record, **83**: 566, 1929. From Chem. Abst., **24**: 1450, March 20, 1930. An effluent is considered satisfactory when it does not contain more than 30 p.p.m. of suspended matter, or when its suspended matter does not absorb in 5 days at 65°F. more than 20 p.p.m. dissolved oxygen. Most so-called intractable wastes can be purified if mixed with a sufficient quantity of domestic sewage, but trouble is experienced when they are irregularly discharged into sewers in large quantities, and when they contain large quantities of suspended solids, or are strongly acid or alkaline. Disposal of gas liquor by dilution is not always a cheap method. Any domestic sewage or trade waste can be purified at a cost. The chief hindrances to the purification of rivers are not technical, but financial, legislative, and administrative.—*R. E. Thompson.*

The Use of Rain Water in the Silk Industry. GIOVANNI BARONI. Prog. ind. tintorie tessili, **28**: 204–14, 1929. From Chem. Abst., **24**: 1517, March 20, 1930. The sulfoleates and analogous compounds used in treatment of raw silk, give with hard water insoluble soaps that dry on the silk and cause damage in the degumming and dyeing. Rain water is very suitable because it contains a maximum of 0.00393 gram of carbon dioxide per liter and dissolves a maximum of 0.065 gram calcium carbonate.—*R. E. Thompson.*

Status of Stream Pollution in Iowa. A. H. WIETERS. Proc. Iowa Acad. Sci. **35**: 63–7, 1928. From Chem. Abst., **24**: 1450, March 20, 1930. Acting

under provisions of the Iowa stream pollution law, adopted in 1923, the Department of Health, since July 1, 1925, has been studying the pollution of Lime Creek, Shell Rock River, and Cedar River. Work carried out to date has shown very definitely the need for an extensive investigation of each stream. So many factors affect the self-purification of streams that there exists no formula by which one can from knowledge now available accurately predict the effect upon a stream of a given amount of sewage or trade waste.—*R. E. Thompson.*

Comparison of Diffused-Air and Stream-Flow Aëration in Purification of Packing-House Wastes. MAX LEVINE, HARRY N. JENKS and F. G. NELSON. Sewage Works J., 1: 425–30, 1929. From Chem. Abst., 24: 1450, March 20, 1930. Comparison of results obtained on a packing-house waste having a chloride content of 2250 p.p.m. NaCl and a 5-day biological oxygen demand of 953 p.p.m. shows a more rapid reduction of organic nitrogen, oxygen consumed, and 5-day biological oxygen demand by the stream-flow method than by diffused aëration. The latter gave a better-appearing effluent. Both methods were capable of quickly developing a satisfactory activated sludge which could be maintained in good condition.—*R. E. Thompson.*

Good Filtration Pays in Many Ways. REGINALD TRAUTSCHOLD. Paper Trade J., 90: 2, 44–52, 1930. From Chem. Abst., 24: 1507, March 20, 1930. Discussion of the importance of water filtration in pulp and paper mills and of proper methods for obtaining the best results.—*R. E. Thompson.*

New Results of Research Regarding the Protection of Boilers from Scale by Means of Organic Colloids. W. E. v. GROMOW. Centr. Zuckerind., 37: 1377–9, 1929. From Chem. Abst., 24: 1537, March 20, 1930. Discussion.—*R. E. Thompson.*

The Determination and Extraction of Phenols in Waste Water from Brown Coal Distillation Plants. P. ROSIN and H. JUST. Z. angew. Chem., 42: 965–8, 984–7, 1002–7, 1929. From Chem. Abst., 24: 1489, March 20, 1930. Cresols and dibasic phenols like pyrocatechol occur in wastes from brown coal distillation plants, but there is little phenol. To determine phenols, a 50-cc. sample of waste is treated with 0.5 cc. 15 percent sulfuric acid and extracted 4 times with 20-cc. portions of benzene-quinoline solution (60 percent). The extract is treated once with 20 cc. and twice with 10 cc. of 10 percent sodium hydroxide solution, the phenolates so obtained are diluted to 1000 cc., and then 50cc. of this solution is placed in a glass-stoppered bottle containing 50 cc. potassium bromide solution (1.670 grams/liter) and 50 cc. of potassium bromate solution (6.00 grams/liter) 10 cc. of 15 percent sulfuric acid added, the mixture shaken thoroughly and then allowed to stand 2 hours. Twenty cubic centimeters of 10 per cent potassium iodide solution is added; after 10 minutes contents of the bottle are rinsed into a porcelain dish and iodine is titrated, using starch as indicator. Experiments showed that tribromophenols are formed, with simultaneous liberation of 3 hydrobromic acid molecules per molecule of phenol; thus 6 Br are required for each phenol molecule. An average molec-

ular weight of 109 is assumed for the phenols present. Confirmatory tests were run on raw and purified phenols by a gravimetric process and check results obtained. Detailed reports on extraction of phenols by solvents like quinoline-benzene, benzene, aromatic hydrocarbons, paraffin hydrocarbons, etc., show that benzene with 20 percent aniline added gave the best results, if price be considered, but for laboratory purposes benzene with 20 per cent quinoline is even more efficient. By using 25 percent benzene-aniline with counter-current washing about 75 percent of the phenols were removed from waste waters of brown coal distillation plants. Recovery of the solvent by distillation with steam is proposed.—*R. E. Thompson.*

Water Supply for Rockhampton, Queensland. G. B. SYMONDS. Commonwealth Eng., **17**: 113–6, 1929. From Chem. Abst., **24**: 1686, April 10, 1930. Methods of application of alum and lime for turbidity are given. Results of tests are given showing relations between pH value and turbidity. Analyses of crude and reservoir waters included.—*R. E. Thompson.*

Meteorological Conditions Associated with High Tides in the Thames, England. J. S. DINES. Air Ministry Meteorological Office Geophysical Memoir No. 47. H. M. Stationery Office, 2s. 6d. net.; Engineer, 1929, **148**: 42. Past records show that there had been no tide between 1881 and 1927 high enough to overflow Thames defences at their present level. Author gives results of extensive study of meteorological state. Close association was found between geostrophic winds of 60 m.p.h. and over from N.W. or N. over the North Sea and a raised water level at Southend; rise of four feet, or over, could be forecasted. Such disturbances, however, tend to avoid high tide and to pass without danger of flooding; so that, without further knowledge of reason for this behavior, it is not practicable to issue useful warnings of Thames floods.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Report on Thames, England, Floods. A. T. DODDSON. Air Ministry Meteorological Office Geophysical Memoir No. 47. H. M. Stationery Office. 2s. 6d. net; Engineer, 1929, **148**: 42. As result of Thames floods of January 6–7, 1928, Tidal Institute of University of Liverpool was requested to investigate causes of such floods. Report deals with: **I. The Study of Storm Surges; II. Statistical Investigations; III. The Effects of Land Water; IV. Probabilities.** Variations in tide level at Southend were studied and it was found that large disturbances occur, 5-foot surges being quite common and even 11 feet being recorded on one occasion. Should such surges coincide with high water, results might be disastrous. Study of meteorological conditions showed that investigations further afield were necessary and study of tidal movements at different places was made. Variations in land water in Thames were found not to be of primary importance. Once in eighteen years is considered to be much too high an estimate of probability of such floods taking place in London; about once in sixty years being more likely.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Shellfish Pollution. R. W. Dodgson. Ministry of Agriculture and Fisheries. Fishery Investigations 1928, 10: No. 1. Series 2. **Report on Mussel Purification.** London. His Majesty's Stationery Office, 1928; Nature, 1929, 123: 900. Contains summary of causes and effects of shellfish pollution, and describes research which has led to method for purifying sewage-polluted shellfish. Diagnosis of and remedies for diseases attributed to eating shellfish are discussed. Mussel-poisoning is of three types; the erythematous, the paralytic, and the bacterial food-poisoning. If proper precautions taken, danger of contracting the fatal paralytic type is negligible. Other infective germs of fecal origin are also present in shellfish and may cause epidemics. Author urges compulsory sterilization of sewage from hospitals housing infectious cases, but it is impossible thus to protect shellfish from pollution by other sewers. Author has studied physiology of the mussel. By means of ciliated gills, mussel is able to filter all suspended matter and germs from water which passes through its body, and later to collect all this polluting matter in a sticky mucus and discharge it into the sea. Discovery of this phenomenon of self-purification gave clue for method now adopted to obtain clean shell-fish. The gathered mussels, carefully freed from mud by hosing with fresh water, are placed in tanks of sea water, previously sterilized with 3 p.p.m. of chlorine from bleaching powder and, since chlorine inhibits physiological activities of mussel, dechlorinated with thiosulphate. Mussels left overnight in this pure water eject practically all infective germs. Discharged feces are washed from tank and shells cleaned again externally with chlorinated (3 p.p.m.) water. Purified mussels are then packed in sterilized sacks for market. Method is hygienically and commercially successful. Tanks can be operated by one trained superintendent and one unskilled assistant. In third part of report, author severely criticises present bacteriological methods for identification and indication of bacteria, with particular reference to shell-fish analysis.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

A Quantitative Study of the Effect of Ultra-Violet Rays Upon the Bacteriophage. S. L. Baker and S. H. Nanavutty. Brit. J. of Exp. Path., 1929, 10: 45; Physiol. Abst., 1929, 14: 5, 323. Survival curve for *B. coli* under irradiation from ultra-violet rays differs from that for antiseptics and heat. Comparison was made of effect of irradiation upon bacteriophage and upon trypsin, diastase, lysozyme, complement, and haemolytic amboceptor. Susceptibility of these was found to be less than that of bacteria except in case of bacteriophage, where susceptibility was of same order as that of bacteria. Relative lethal effects on bacteria and bacteriophage of three regions of mercury vapor spectrum were compared. Wave-lengths longer than 3000 Å, had no lethal action in either case; while, in both cases, relative lethal efficiency of whole region 3000–2000 Å to that of region 3000–2650 Å was about as 4.4:1. View is supported that bacteriophage is of nature of a virus and has little in common with ferments.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Investigations of the Effect of Light on Bacteria. F. v. Gutfeld and L. Pincussen. Cbl. für Bakt. Parasitenk., und Infektionskrankh. Abt. I, 1928,

109: 107. Increased effect of light on colloidal suspensions in presence of certain ions which increase degree of dispersion of colloids suggested that addition of certain salts to bacterial suspensions might affect action of ultraviolet rays. Tests were made with bacteria suspended in distilled water and in M/5 and M/10 solutions of potassium, calcium, sodium, and magnesium chlorides, respectively. No difference appeared with *B. coli*, *B. typhi*, *B. paratyphi*, and *B. dysenteriae Shiga-Kruse*. With *Staphylococcus aureus*, interval before appearance of attack on the bacteria was three times as great with calcium chloride as with distilled water. With *B. diphtheriae* also, calcium chloride exercised strong protective action. References to literature are given.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Disinfecting Action of Metals. J. VIGNATI and P. SCHNABEL, Cbl. für Bakt., Parasitenk., und Infektionskrankh. Abt. I, 1928, **109**: 464. **Part I. Disinfection and Arrest of Development by Copper Salts.** Series of investigations on action of copper salts on bacteria were carried on with view to distinguishing actual killing of bacteria from arrested development and to determining chemical and physical nature of process. It was found that copper salts coagulated bacterial colloids as they would albumen solutions. This was confirmed by increased Tyndall effect in nephelometric observations. If process extends to the bacterial body, it cannot, as in case of a colloidal solution, be reversed. Concentrated copper solutions kill bacteria rapidly, but dilute solutions may leave them in arrested condition from which they may be brought back to active life. In practice such bacteria may be regarded as dead, for it is unlikely that optimum conditions for revival will be present. Disinfection is therefore to be distinguished as a destructive process while arrest of development is a withering process. **Part II. The Process of Disinfection.** It was found that complex compounds of thiosulphate with copper and other metals have in themselves a low disinfecting effect. They are not toxic to bacteria as long as they are un-decomposed, but in decomposition they set free copper compounds which are toxic. In aqueous medium, copper ions in combination with peptone can be set free by sodium thiosulphate; resulting copper thiosulphate on decomposing has disinfecting effect. Disinfecting action of metals attacks protein components of bacterial body more than lipoid parts.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Comparative Investigations of the Resistance of Different Leptospira (Spirochaetes) against Outside Influences. S. ANJOW. Cbl. für Bakt., Parasitenk., und Infektionskrankh, Abt. I, 1928, **109**: 61. After summary of previous work, author describes investigation of nine types of pathogenic and two of water *Spirochaetes*, including oligodynamic effects of metals, influence on growth of serum concentration and of different salt concentrations, influence of bile, resistance to saponin and to acids, and influence of temperature. Full details of methods of experiment and of results are given. Investigation showed that pathogenic *Leptospira* and morphologically similar saprophytic water *Leptospira* have in common strong resistance against saponin and strong sensitive-

ness to bile and acids, but differ in their resistance against oligodynamic action of metals and in symbiosis with other bacteria. Author divides the *Leptospira* into three classes, according to resistance offered to outside influences, namely: (1) pathogenic *Leptospira* of *Icterohaemorrhagiae* group, which are least resistant; (2) pathogenic *Leptospira* of *Akiyama hebdomadis* group, which are more resistant than group (1); (3) saprophytic water-*Leptospira*, which are strongly resistant. Bibliography is added.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Immunological Relations between Different Leptospira. S. SHIOZAWA. Cbl. für Bakt., Parasitenk., und Infektionskrankh., Abt. I, 1928, **109**: 80. Comparative examinations of eleven forms of *Leptospira*. Methods of experiment and results are described.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

The Cobble Mountain Water Project of Springfield, Mass. JAMES B. PORTER. Water Works and Sewerage, **74**: 225–30, 1930. Project includes diversion tunnel, dam, reservoir, spillway, two gate houses, power tunnel, three penstock lines with surge tank, power house, and seven highways. Cost for water supply alone was estimated at $4,000,000; by proper location of dam, power project was developed at additional cost of $2,000,000. Annual rental of $270,000 for power will greatly reduce carrying charges and make construction of such a large project feasible. Watershed covers 11,000 acres and provides average runoff, at dam site, of 58 m.g.d. Reservoir will have capacity of 22.5 billion gallons, area of 1120 acres, and average depth of 58 feet. When main dam has been completed, diversion tunnel (concrete lines) will house two 48-inch pipe lines, which will be opened only in case of extreme floods, or when power company has drawn water level down to elevation of power tunnel. Main dam, with maximum height of 255 feet, will be world's highest hydraulic fill dam. With top width of 50 feet and bottom width of 1500 feet, top length of 700 feet and bottom length of 80 feet, it will contain 1,800,000 cubic yards of material, including 400,000 cubic yards of rock. Specifications for core require that 10 percent must be under 0.01 mm. New method of core analysis has been perfected, utilizing principle of elutriation and based on STOKES' law. Other laboratory tests include turbidity, settling, percolation, and capillarity. Entire project, with exception of surge tank, penstocks, and power house, is being built by Springfield Board of Water Commissioners.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Sterilization of Water Mains. ELAN P. STEWART. Water Works and Sewerage, **77**: 191, 1930. Whenever water mains are repaired, or new pipes installed, liquid chlorine is used to sterilize all sections that may possibly have become contaminated. Portable chlorinators have proven very satisfactory for this work.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Correcting Corrosive Water at Institution. G. M. RIDENOUR. Public Works, **61**: 122–3, 1930. New Jersey State Institution reports persistent and

serious case of corrosive water. Water is secured from 260-foot well driven in yellow sand, blue sand, and clay. Analysis at well gave: pH, 5.5; carbon dioxide acidity, 14.0 p.p.m.; total alkalinity, bicarbonate, 10.0 p.p.m.; dissolved oxygen, 2.00 p.p.m.; and hardness, 22 p.p.m. Tap-water contained, in addition to above, 4.9 p.p.m. of ferric iron. Installation of deaërator reduced acidity to 2.0 p.p.m. and increased pH to 6.2; but failed to check corrosion. VON HEYER'S marble test was used to determine position of equilibrium between carbonate, bicarbonate, and carbon dioxide such that slight coating of carbonate would be deposited on pipe surfaces and thus serve as protection from oxygen or acids. Lime was accordingly applied at pump suction in sufficient quantities to maintain pH of 7.7 to 8.0. This resulted in carbon dioxide acidity of 0.2 p.p.m., bicarbonate alkalinity of 43 p.p.m., and occasional carbonate alkalinity up to 8 p.p.m. Conditions were markedly improved after 2 months of lime treatment. Approximately 30 pounds lime are used per hundred thousand gallons of water.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Cold Weather Troubles in Filtration. C. T. HOUGH. Waterworks and Sewerage, **74**: 260, 1930. From experience obtained by treating water supply for Lawrence, Kansas, following conclusions are drawn: (1) that ample retention period should be considered in design of settling basins for application of chlorine and also for softening treatment at low temperatures; (2) that better results will be obtained by double chlorination, or by application of chlorine prior to application of lime; and (3) that effectiveness of chlorine at low temperatures depends both upon contact period and upon pH value of water. —*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Safety in Dam Construction. ALLEN HAZEN. Public Works, **61**: 106–110, 1930. Outlines and suggests methods of solving some uncertainties in design and construction of dams, which have caused failure of such structures. Following types of dams are considered: masonry; rock-fill; and earth, either (*a*) dry filled with masonry on earth core, or (*b*) hydraulic fill. Diagrams and tables are included.—*C. C. Ruchhoft.*

Cleaning Filter Sand at Purification Plants. EMIL K. VENTRE. Public Works, **61**: 93, 1930. Caustic soda method is adopted where alum is used as coagulant, or where water is high in organic matter, or where pH of filter influent is 7.0, or slightly less, and trouble is chiefly due to unicellular algae and protozoa. Hydrochloric acid treatment is recommended where iron and lime are used as coagulant, or where for any reason incrustation on sand is mostly carbonate, with little organic matter.—*C. C. Ruchhoft.*

Installing 20-inch Mains by Jacking Method. Anon. Water Works and Sewerage, **74**: 237–8, 1930. Two lines of 42-inch corrugated iron pipes were jacked under double track railroad bed without any interference to traffic. Twelve-foot sections of pipe were connected as jacking proceeded by field-riveted joint. Mains were laid through these conduits. Advantages include: No roadbed maintenance, quicker and more economical construction, protec-

tion of water mains from traffic vibration, and protection of roadbed in case of broken main.—*C. C. Ruchhoft.*

Specifications for Drilled Wells. W. Scott Johnson. Waterworks and Sewerage **74**: 250, 1930. Missouri State Board of Health and State Geologist in 1925 formulated specifications to be included by engineers in all contracts for construction of municipal water supplies from wells. Following items are included: cutting samples, seal, analysis of water, records, approval and technical specifications covering all well pumping machinery.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Maintaining Chemical Balance to Resist Corrosion. Charles P. Hoover. Water Works and Sewerage, **77**: 287, 1930. Remedies against corrosion include: (1) preheating to drive off oxygen; (2) caustic alkalinity content of from 30 to 50 p.p.m. in excess of that required to soften; the higher the pH, the less iron will be dissolved; (3) passage through bed of scrap iron, or filings; (4) pipe coatings of zinc, cement, or tar; (5) sodium silicate, of which 20 p.p.m. is sufficient to stop corrosive action almost entirely; (6) treatment that will induce deposition on inside of pipe of impervious film which will prevent direct contact between water and iron; as, by saturating the water with calcium carbonate.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Mixing Basins: Time of Mixing. John R. Baylis. Water Works and Sewerage, **77**: 279, 1930. Mixing periods in filtration plants vary from 3 minutes to 90 minutes; but generally the mixing time in newer plants is from 30 to 60 minutes. Factors influencing time of floc formation are quantity of coagulant, time of mixing, temperature, violence of agitation, and character of water. Discussion of these phases is included.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

The Water Works of St. Louis, Mo. Anon. Water Works and Sewerage, **77**: 177–183, 1930. St. Louis has two independent sources of water supply, Chain-of-Rocks plant, on the Mississippi, and Howard Bend plant, on the Missouri. At Chain-of-Rocks, muddy waters of Mississippi are drawn through intakes and tunnels in solid rock under the river to wet well and are thence pumped to storage basins, where sand and heavy sediment are removed, water passing on to lime-mixing process. Before entering primary settling tanks, iron sulfate is added and 34 hours settlement is then allowed. Before going to secondary coagulation basins, aluminum sulfate and preliminary dose of chlorine are added. From secondary coagulation basins, water flows through two secondary settling basins and then through rapid sand filters to drawing conduit chamber. Here it is again chlorinated before being conducted to pumping stations. Reservoirs store excess water. Missouri water receives almost similar chemical and mechanical treatment.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Odor and Waste Control at Charleston, W. Va. Lawson Haynes. Water Works and Sewerage, **77**: 266, 1930. For slight phenol tastes, 0.12 to 0.18

p.p.m. of potassium permanganate is satisfactory; but this will not eliminate taste when large amounts of phenol are present. Color imparted by permanganate disappeared after settling. Anhydrous ammonia, applied to settled water before filtration in addition to permanganate, removed phenol tastes; but no residual chlorine could be detected in clear well, due to reaction of ammonia on chlorine. Further experiments showed that best treatment for phenol taste elimination was addition of chlorine to raw water at point of entry to basin.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Pre-chlorination of Filters. JOHN F. KINGSLEY. Water Works and Sewerage, **77**: 194–5, 1930. Pre-chlorination of raw water at Newburgh, N. Y., has accomplished several beneficial results without any significant increase in cost of operation. It eliminates short filter runs, reduces size and number of mud balls, eliminates surface cracks and wall cracks in sand bed, and promotes color removal without increasing coagulant dose. High velocity washes are not necessary when water is prechlorinated.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Embrittlement and Protection of Steam Boilers. FREDRICK G. STRAUB. Power Plant Eng., **35**: 190–193, 1931. Two factors common to all embrittled boilers are caustic boiler water and highly stressed areas adjacent to rivets and tubes. Na_2CO_3 decomposes in boiler to give NaOH and CO_2. Waters containing SO_4 and treated with excess of Na_2CO_3 will have excessive ratio of NaOH to sulfate. Two conditions under which Na_2CO_3 will tend to be in excess of sulfate are: (1) In well water naturally containing Na_2CO_3. (2) As result of treatment with excess soda ash. Zeolite treatment may also cause this condition. A ratio of three parts Na_2SO_4 to one of Na_2CO_3 is generally sufficient for practically all boiler pressures.—*G. L. Kelso.* (*Courtesy Chem. Abst.*).

Quick Freezing of Pipes for Repairs. Anon. Power Plant Eng., **35**: 345, 1931. When necessary to make new connections or repairs in pipe lines carrying water, or solutions, and unprovided with shut-off valves, it is possible to block off sections by freezing in a plug of ice. This is most easily done by use of "dry ice" (solid CO_2). Dry ice is at temperature of −109.6°C., and 2-inch water main can be frozen with it in 20 minutes. Dry ice is readily available everywhere.—*G. L. Kelso* (*Courtesy Chem. Abst.*).

Concentration Control of Boiler Water. HERBERT S. WHITON. Power Plant Eng., **35**: 452–454, 1931. Concentration in boiler can be measured, (1) by calibrated hydrometer; (2) by chemical determination of carbonate, bicarbonate, hydroxide, sulfate, chloride, and phosphate ions; (3) by electrical measurement of specific conductivity of sample.—*G. L. Kelso* (*Courtesy Chem. Abst.*).

Iodine Prophylaxis and Endemic Goiter. A. T. CAMERON. Canadian Public Health Journal, **21**: 529–582, November, 1930. Abstract: Journal American Medical Assoc., **96**: 3, 323, January 17, 1931. Evidence shows that there is

close relationship between deficiency of iodine in the diet and occurrence of simple goiter, and that such deficiency leads to the goiter. There is strong evidence that in certain regions water-borne infection is a predisposing factor, but this probably acts through an effect on iodine metabolism. Iodine prophylaxis, particularly use of iodized salt, is discussed. The problem applies to domestic and other animals as well as to man.—*John H. O'Neill.*

NEW BOOKS

Elements of Water Bacteriology: With Special Reference to Sanitary Water Analysis. SAMUEL CATE PRESCOTT and CHARLES-EDWARD A. WINSLOW. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 6 by 9 inches; pp. 219. $2.50. Reviewed in Eng. News-Rec., **106**: 490, March 19, 1931, by HARRY E. JORDAN.—*R. E. Thompson.*

Handbuch der Wasserversorgung. ERWIN GROSS. München und Berlin: R. Oldenbourg. Cloth; 7 by 10 inches; pp. 485. 22 marks. Reviewed in Eng. News-Rec., **106**: 492, March 19, 1931.—*R. E. Thompson.*

Gas Welding and Cutting. Compiled by the Educational Committee of the American Welding Society. Revised edition. New York: American Welding Society. 78 pp. From Chem. Abst., **24**: 5012, October 20, 1930.—*R. E. Thompson.*

Practical Oxy-Acetylene Welding. R. GRANJON, P. ROSENBERG and A. DESGRANGES. Translated by D. RICHARDSON. London: The Welding Journal. 181 pp. 3s. 6d., net. Reviewed in J. Inst. Metals, **43**: 738, 1930. From Chem. Abst., **24**: 5709, November 20, 1930.—*R. E. Thompson.*

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L'eau souterraine. Recherche, captages par sondages. V. PETIT. Paris: Ch. Béranger. 130 pp. F. 52. Reviewed in Chimie & industrie, **25**: 268, 1931. From Chem. Abst., **25**: 1610, April 10, 1931.—*R. E. Thompson.*

Proceedings of the Ninth Annual (Kansas) Water Works School. 3: Kansas Water Works Association, University of Kansas. Lawrence, February 11–12–13, 1931. 139 pp. **Proper Well Construction.** A. G. FIEDLER. 13–20. Discussion of factors of location, type of well, protection at surface and under ground, chlorination of completed wells, and abandonment and plugging of unused wells. **Water Supply Service offered by Kansas Geological Survey.** KENNETH K. LANDES. 21–23. Description of water-bearing geological strata underlying Kansas and the characteristics of supplies available from them. **Methods for the Biological Examination of Water.** W. C. PURDY. 24–29. Brief résumé of matters to be considered in the field survey, sampling, con-

centration, and examination in respect to microscopic examination. **The Interpretation and Use of Biological Data in the Water Works Field.** W. C. PURDY. 29–35. Continuation of previous paper, discussing sources of taste and odor troubles among plankton. Paper is accompanied by extensive table showing amounts of copper sulphate or chlorine required for destruction of different organisms. **The Fire Stream Capacity of a Water Distribution System.** J. O. JONES. 36–39. Analysis of hydraulics of hypothetical municipal distribution system under several possible conditions of flow. **Designing Extensions to a Water Distribution System.** R. O. RUBLE. 40–47. Existing system to be extended should be thoroughly surveyed and evaluated. Its value may be considerably improved by addition of strengthening mains at strategic points. Location of supply works, probable future direction and amount of growth of city with topography of the town site, materials of the existing system, amount and character of existing and proposed pavements, all are related. Requirements and recommendations of National Board of Fire Underwriters constitute good basis for design. Elevated storage provides reserve against failure of pumping equipment and serves as well to stabilize pressures in parts of system remote from pumping station. Economics of use of larger pipe sizes as against increased pressures is discussed at length. **Practicable Accomplishments in the Operation of Small Sewage Treatment Plants.** W. SCOTT JOHNSON. 48–52. **The Design and Operation of the Sewage Treatment Plant at Ottawa, Kansas.** M. F. VEATCH. 53–55. **Recent Developments in Odor and Taste Control in Water Treatment.** H. B. CRANE. 56–60. Odors and tastes in water may be caused by organic compounds, or their chlorine derivatives, or by inorganic compounds, such as iron, or hydrogen sulphide. They may be combated by both preventive and curative methods. Ammonia-chlorine, or chloramine, treatment is one of the best preventive methods. Destruction of taste and odor producing substances with excess chlorine followed by dechlorination with sulphur dioxide, sodium bi-sulphite, or activated carbon; or direct adsorption by carbon are effective curative measures. The paper is principally concerned with descriptions of nature and use of activated carbons. **The Advantages of Combined Mixing and Aëration.** HERMAN ANDERSON. 61–65. Operating results of use of Aer-O-Mix, combined aërator and mixer, included speedier floc formation, reduced chemical dosage, and removal of tastes and odors. **Application of the Treasury Department Standards to Kansas Water Supplies.** CASSANDRA RITTER. 66–71. Sources of bacterial pollution and standard tests for bacteria are discussed. Paper concludes with statement of status of Kansas supplies as judged by Treasury Department standard. **The Business Affairs of a Public Utility.** W. O. MYERS. 72–77. Methods used in ordinary business affairs are not always suitable for a public utility. Nature of the relationship between utility and public should dictate procedure in certain cases. **Accidents and their Causes.** EARLE G. BROWN. 78–84. Analysis of accidents and their causes in State of Kansas for several years past. **Operating Characteristics of Induction Motors.** DUGALD C. JACKSON, JR., 85–91. Clear and concise statement of the important relation of efficiency, power factor, and torque of induction motors, often overlooked in application of such motors to special services. **Water Ratings for**

1930. EARNEST BOYCE. 92–96. Of fifty-three surface water supplies in Kansas, twenty-two have perfect scores, based on their bacterial quality and regularity of analysis. Forty-six of the fifty-three surface water and one hundred forty-four ground water supplies met the Treasury Department standard. **A Review of Municipal Water Softening Practice in Kansas.** R. E. LAWRENCE. 97–101. Kansas is classed as a hard-water state. Lawrence, Topeka, Manhattan, Iola, Marian, and Lincoln are now softening their municipal supplies. Neodesha is constructing a softening plant. Many small plants use lime for coagulation purposes and accomplish a small amount of so tening incidentally. Treatment methods and results attained at the six plants are discussed. **Some Filtration Kinks.** L. B. MANGUN. 102–105. Overloading, filter bed troubles, short runs, loss of sand, and taste and odor problems are discussed from standpoint of operator. **Controlling Wash Water Rates by Sand Expansion.** GEO. F. GILKISON, 106–108. Experiments at Kansas City, Missouri, indicate that with wash water temperature of 82°F. and washing rate of 24-inch rise, sand expansion was 33 percent; whereas, with wash water temperature of 33°F. and same rate of rise, expansion was 53 percent. It was not possible to get 40 percent expansion when wash water temperature was above 70°F. Tests indicated that no saving of wash water was possible by these increased rates and that no benefits were gained by washing at rates which produced sand expansion in excess of 40 percent. A filter sand bed expansion measuring instrument is described and shown in sketch. **The Use of Ammonia in Water Treatment.** SELMA GOTTLIEB. 109–112. Chief claims now made for ammonia-chlorine treatment are prevention and correction of objectionable tastes and odors in water, better sterilization than by chlorine alone, prevention of aftergrowths in reservoirs and distribution systems, and reduction of necessary chlorine dosage. Operating procedure and results obtained at several plants now using this treatment are discussed. **How Lincoln, Kansas, Secured a Water Softening Plant.** M. J. REES. 113–115. Supply from wells in sandstone has total hardness of 440 p.p.m., of which 227 parts are carbonate, and 213 parts, non-carbonate hardness. By use of old power plant as inclosing structure and building of mixing chambers, settling basins, and filters of concrete, small plant of nominal capacity of about 200 gallons per minute has been constructed by force account at cost of less than $7,500. This plant reduces hardness to 166 p.p.m., of which 76 parts are carbonate, and 90 parts, non-carbonate hardness. **The History and Development of the Independence Water Supply.** J. C. GORDON. 116–120. Record of growth and development. **Mottled Enamel: a Dental Defect and Its Occurrence in Kansas.** R. W. KEHR. 121–131. Survey of four towns in Kansas showed that over 90 percent of the children using city water from birth acquired mottled enamel; whereas only about 10 percent of those who used city water only at school were affected. Attempt was made to discover any relation which may exist between chemical qualities of the waters and prevalence of dental defects; but without marked success. "While calculated sodium bicarbonate shows a rather definite relationship, its presence is by no means suggested as a possible cause for mottled enamel. The sodium bicarbonate, or both that and the low total hardness, may possibly be contributing factors or associated with the real cause in some other manner." **Factors in Swimming Pool Design.** M. P. HATCHER. 132–

135. Bath houses of durable and fireproof materials, equipped with suitable means for handling clothes and with adequate shower and toilet facilities, are important. Pool should be of economical construction, with every provision for safety, proper proportion of deep and shallow areas, and adequate means for distribution and collection of circulating water, and should be adaptable for water races and sports. Its size should be proportioned roughly for one to three percent of population attending during average day of season. Attendance on peak days will amount to two to four times the average. Filtration and circulation of the water are now usually employed, using some coagulant. Alkalinity of pool water may be maintained by use of soda ash. Smarting of the eyes, so generally attributed to chlorine, will not be experienced if alkalinity is kept above pH of 7.2 to 7.4 and chlorine residual is kept below 0.5 p.p.m. **The Use of Admixtures in Concrete.** W. C. McNown. 136–139. Author's conclusions. "(1) That admixtures in general do increase the workability of concrete. (2) It is the experience of the writer that most admixtures decrease the strength of concrete. (3) The greatest benefit is derived from the use of admixtures where the materials used are harsh for one or more of the reasons stated above. (4) Extra cement is the only material that the writer has used that increases workability while at the same time increasing the compressive strength of the concrete. (5) Other things being equal, durability may be increased by increasing the density of the concrete, and this may be accomplished as readily by the addition of cement as through the use of foreign materials. (6) In the matter of uniformity the writer has found upon several occasions a somewhat greater uniformity of strength as between the several test specimens taken from a batch containing hydrated lime. (7) The use of an admixture in concrete has the disadvantage of requiring one additional material to be obtained, stored, and separately placed in the mix."—*R. L. McNamee.*